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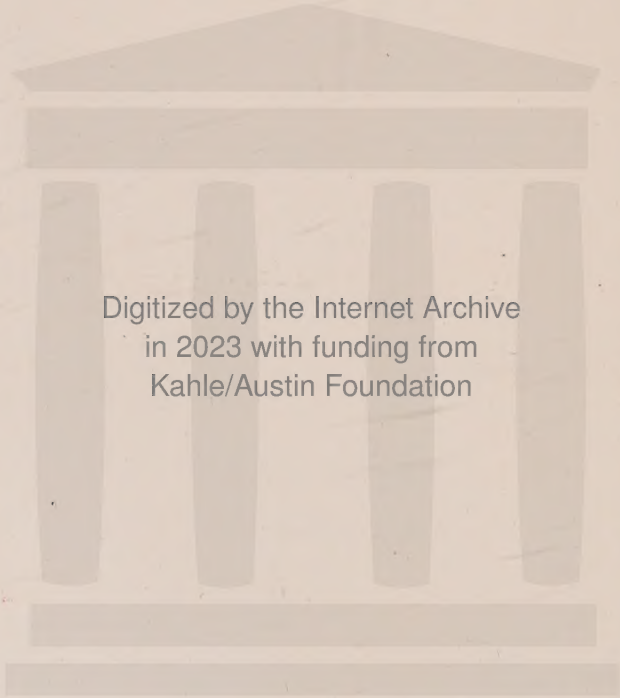
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GEOLOGISTS' ASSOCIATION:

RECORD OF EXCURSIONS.

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GEOLOGISTS' ASSOCIATION.

A

RECORD OF EXCURSIONS

MADE

Between 1860 and 1890.

EDITED BY

THOMAS VINCENT HOLMES, F.G.S.,

AND

C. DAVIES SHERBORN, F.G.S.

LONDON: EDWARD STANFORD,
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PREFACE.

The task of drawing up a Record of the Excursions of the Association was originally entrusted to Mr. Topley, whose many engagements, however, had prevented him from giving it any definite form when it was handed over to me. From him I learned that the excursions were to be arranged and edited so as to form a useful and handy guide to the geology of the places visited.

The Record being primarily intended for the use of members (a decided majority of whom have joined the Association during the last ten years), it appeared to me that its character as a chronicle of past work and workers should not be forgotten. Accordingly every excursion down to the year 1890 has been mentioned separately, and where many reports of visits to the same locality exist I have either suppressed the shorter and retained the fuller, or have given from each account that which is not to be found elsewhere. This course seemed preferable to the compilation of one account from various reports on the following grounds. Visits to the most popular places have been seldom made except at intervals of, at least, five or six years. Consequently in their case we have to deal with the work of five or six different directors or reporters, and with descriptions of sections which must have varied very considerably during a quarter of a century or more. It seemed better, therefore, to avoid confusion by keeping each report separate, and each reporter responsible for his own account. Indeed, in but few cases is there much repetition, the later reporters usually omitting what has been fully described on some previous occasion.

The alterations in the reports as given in the "Proceedings" consist mainly of excisions made in order to reduce the bulk of the Record as much as could be done without injury, the general arrangement and wording remaining unaltered. Of course it by no means follows that the matter excluded is out of place in the original report. Even an after-dinner speech, for example, might have pleasant associations for the partakers of the preceding banquet, though its retention in the Record would certainly be considered useless, if not irritating, by the great majority of readers. It also became obvious during the progress of the work that it would be well to omit reports of excursions of later dates than the year 1884, as during 1885 and since the excursions have been collected together in the November number, instead of being scattered here and there throughout the "Proceedings." But all excursions to the end of 1890 are mentioned, and references to reports of them given. Even without these reports the Record has attained larger dimensions than had been anticipated, partly owing to the addition of many useful illustrations from various sources. It may be worth suggesting that in some cases in which a map or section is not so clear at a glance as could be desired, a little colour will at once give the distinctness needed. Breaks have been made at pp. 224 and 400, so as to allow of binding the volume in three parts, convenient for the pocket.

Though the Record cannot in itself be considered an adequate geological guide even to south-eastern England, it may claim to fill a vacancy hitherto existing in geological literature. Though it will not enable the student to do without Sir A. C. Ramsay's "Geology of Great Britain," Mr. H. B. Woodward's "Geology of England and Wales," or Mr. Harrison's "Geology of the Counties of England and Wales," it occupies ground on which they enter but little. While the writers just named explain the general conformation of a district, or point out the characteristics of its beds as compared with those of equivalent strata elsewhere, in the Record are described many of the spots most important from their geological sections, or for the views they afford of the structure of the surrounding country; while the intending visitor to any of them may learn from it both how to

employ his time most profitably, and how much time will be necessary for his purpose.

For the general shape taken by the Record I am wholly responsible. But having brought it to its present form, it became obvious that it would be impossible to send each report to the original reporter for revision. Consequently, I then asked Mr. Whitaker if he would look through the sheets referring to the country east of a straight line drawn from the Wash to the Isle of Purbeck, and Mr. H. B. Woodward if he would examine those dealing with the districts north and west of that line. Both gentlemen, whose special qualifications for the task I need not discuss, kindly complied with my request, and it gives me great pleasure to acknowledge here the valuable services they thus rendered. I am also greatly indebted to Mr. B. B. Woodward and to Mr. F. A. Bather, who have carefully read the proofs. Thanks are likewise due to Mr. Worthington Smith, the Geological Society, the Essex Field Club, and the Herts Nat. Hist. Society for the loan of illustrations. And, lastly, my co-editor, Mr. C. Davies Sherborn, has not only superintended the passage of the Record through the press, but has added References to the end of each chapter, seen to the illustrations, and made the Index.

T. V. Holmes.

April 20th, 1891.

A

RECORD OF EXCURSIONS

MADE BY THE

GEOLOGISTS' ASSOCIATION,

FROM 1860 TO 1885.

SOUTH-EASTERN COUNTIES.

KENT.

LEWISHAM, BLACKHEATH, AND CHARLTON.

[The sections at *Lewisham* and *Charlton* have generally been visited on the same day, and may therefore be conveniently grouped together here. The first excursion to *Charlton* took place on August 13th, 1860, and the report of its occurrence occupies four lines in the Proceedings (vol. i. p. 64). The first visit to *Loampit Hill*, *Lewisham*, was made in 1868, during the suspension of issue of the Proceedings, while excursions were made to *Charlton* in 1866 and 1869, of which no report appeared. The *Loampit Hill* sections were inspected on May 7th, 1870 (Proc., vol. ii., p. 33), and again on April 25th, 1874, particulars of which follow.]

EXCURSION TO LEWISHAM.—April 25th, 1874.

Director—W. Whitaker, F.R.S.

(Proc. Vol. iv. *pp.* 114-15.)

On reaching Loampit Hill, where the Woolwich and Reading Series is well displayed, the Director gave a general description of the Series as exhibited in the Woolwich district and in the neighbourhood of Reading respectively, and pointed out the special features of the section. The details, taken from Whitaker "Geol. London Basin" (1872), p. 127 (Geol. London, 1889, ii., p. 154), are as follows (Fig. 1) :—

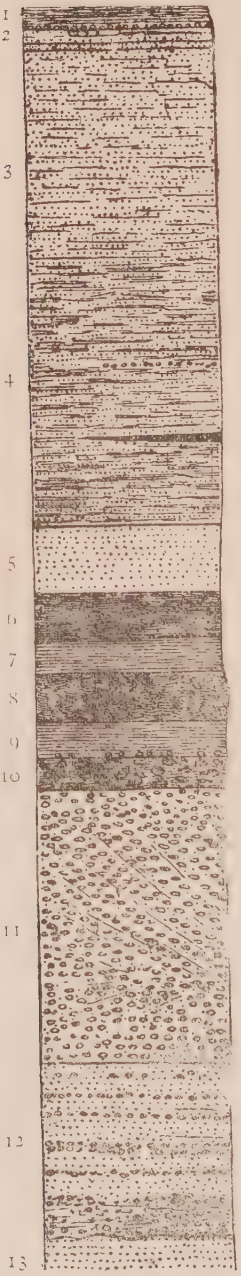


FIG. 1.—SECTION AT LOAMPIT HILL.

LONDON CLAY.

1. Brown Clay, the lower part roughly laminated, about 15 feet on the north, increasing southwards with the dip (about 3°).

2. Basement Bed. Flint pebbles, with clay and sometimes sand, thickening southward from two inches to a foot or more, resting evenly on the bed below.

WOOLWICH BEDS, ABOUT 50 FEET.

3. Light-coloured sand, with partings of clay. At one place a little thin friable buff stone just at top. Near the top a well-marked bed of loose, very light-coloured sand, about 4 inches thick, which makes more plain small faults (from 2 to 9 inches down-throw) about 10 feet, passing down into

4. Laminated Clay, with partings of sand, and with a little selenite. Near the middle many leaves occur. A little below the leaf-bed there is a 4 or 5-inch layer of small flint-pebbles *(a)*, below this is a lignite-bed *(b)*, 3 to 6 inches thick, sometimes with a layer of iron pyrites containing casts of shells; and at one part a sandy lignite at the bottom. Over 10 feet.

5. Brown Sand, about 3 feet.

6. Sandy Clay, about 2 feet.

7. Clay Shell-bed *(Cyrena)*, 1½ feet.

8. Oyster-bed, 2 feet.

9. Clay Shell-bed *(Cyrena)*, a few flint pebbles at bottom, 1½ feet.

10. Yellowish Clay, with race and soft calcareous matter, 1 foot 5 inches (less in parts).

11. Pebble-bed, sandy; the pebbles irregularly arranged (not bedded). ? False bedded in parts, red at the top part, over 12 feet.

12. Bottom Bed. Light-coloured sand, with layers of flint pebbles, at the bottom part greenish sandy clay and clayey sand with a few pebbles; 6 to 8 feet, resting on a worn surface of the next bed.

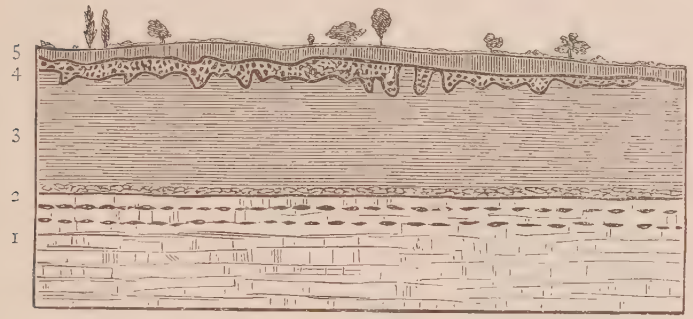
THANET SAND.

13. Thanet Sand, the uppermost 6 or 8 feet, yellowish and iron-stained, then 20 feet or more with a pale pinkish grey tint, total thickness probably 40 feet. Green-coated flints at the bottom, resting regularly and conformably on

CHALK WITH FLINTS.

[Another section is here given, from St. John's, near Charlton, which further illustrates the positions of the deposits in this locality.]

FIG. 2.—SECTION IN CHALK PIT NEAR ST. JOHN'S.



1. Upper Chalk. 2. Green-coated Flints. 3. Thanet Sand. 4. Woolwich and Reading Series. 5. Gravel.

EXCURSION TO CHARLTON.

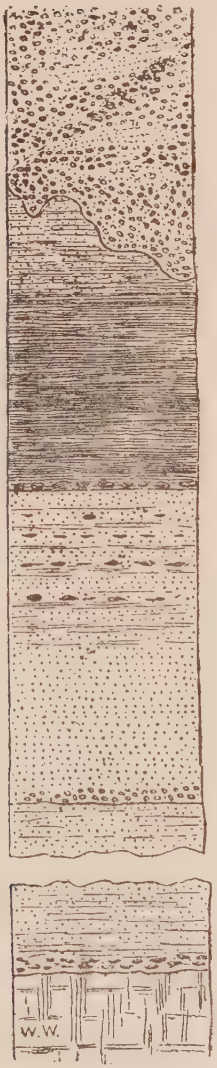
[The following is the earliest report of a visit to *Charlton* that gives any description of the Section.]

APRIL 26TH, 1873.

Director—Professor J. MORRIS, F.G.S.

(Proc. Vol. iii. *p.* 205.)

THE well-known section at Charlton showing the junction of the English Secondaries and Tertiaries was first visited. Professor Morris, after pointing out to the large party assembled around him in the great chalk-pit, the general character of the Chalk and the Lower Eocene beds as they occur in the British Islands, described their foreign equivalents, and the beds which are probably intermediate in age between the Upper Chalk and the Thanet Sands of England. Though we find in our home section that the Thanet Sands appear to lie conformably on the Chalk, it is more than probable that we have lost some hundreds of feet of Chalk, either by sub-aërial or marine erosion, or by decomposition after the deposition of the overlying sands. That some of the Chalk has been removed by decomposition is evident from the occurrence of the well-known bed of green-coated flints at the top of the Chalk, which bed must have been formed by the



quiet and slow removal of the Chalk in which the flints were originally embedded.

The Thanet Sands and the Woolwich and Reading Series are both of limited extent in England, the former formation extending only from Pegwell Bay to a little to the west of London; yet the *Sables de Bracheux* and the *Argile plastique* of the continent of Europe show us that the original extension of these formations was by no means inconsiderable.

[The section is taken from Whitaker, Guide Geol. London (Geol. Survey), 1889, plate.]

EXCURSION TO BLACKHEATH AND CHARLTON.

JULY 1ST, 1876.

Director—Professor J. MORRIS, F.G.S.

(Proc., Vol. iv. *p.* 557.)

LEAVING Blackheath Station the party walked across the Heath to the south-east corner of the plateau, and at the edge of one of the gravel-pits gathered round the Director, who explained the geology of the district. After pointing out the characters of the pebbles composing the so-called "Oldhaven Beds," on which they stood (Proc. Vol. iv. p. 498), Professor Morris stated that these great accumulations of shingle occupied a large area in Kent, forming the plateau of

FIG. 3.—SECTION AT CHARLTON.

1. Oldhaven and Blackheath Beds. Flint Pebbles and Sand; Fossils.
2. Sand and Clay.
3. Clays, sometimes sandy, with Estuarine Shells. } Woolwich and
4. Clay, Loam and Sand. } Reading Series.
5. Sands, part clayey, with Pebbles.
6. Thanet Sand; green-coated Flints at bottom.
7. Upper Chalk.

Blackheath, Lessness Heath, and Plumstead Common, as well as the hills of Shirley, and much of the ground about Bromley and Chiselhurst. The great fault running east and west along the southern side of the Thames, where the ground begins to rise from the alluvial flats, throws down the Lower Eocene beds; and the Chalk (above the river-level at Lewisham and Charlton) is more than 120 feet below the surface of the flat land by the river at the Naval College, Greenwich, and probably correspondingly deep below the marshy land of the northern side of this part of the Thames Valley. The escarpment parallel with the fault is capped for the most part by the Pebble-beds, and is indented by small ravines cut by the water issuing at the junction of these porous beds with the clayey Woolwich Beds below.

[No additional details of the Charlton sections are given in any subsequent report, but some are referred to in Dr. Lavis's paper mentioned below.]

CHARLTON, BLACKHEATH, AND LEWISHAM.

APRIL 30TH, 1881.

Director—J. LOGAN LOBLEY, F.G.S.

(Proc., Vol. vii. p. 142.)

AFTER visiting the great pit at Charlton to see the junction of the Chalk and Tertiary Beds, the party proceeded to the almost equally famous section at Hanging-Wood Hill, displaying the Woolwich shell-beds. The Upper and Lower Cyrena beds are very well developed and shells, in good condition, may be obtained in abundance. The shells are *Cyrena cuneiformis*, *C. depredita*, and *C. cordata*. The shell-beds also yield amongst other species the gasteropods *Melania inquinata*, and *Cerithium funatum* in considerable abundance, but the "Ostrea-bed" of the Ballast-pit section thins out at this place. Overlying the shell-beds we find the "Plant-bed," noticed by Dr. H. J. Johnston Lavis, in 1876 (Proc., vol. iv. p. 528) containing Dicotyledonous leaves and seed-vessels, but it is not nearly so well developed here as at Lewisham and at Bromley.

On reaching Blackheath, the party assembled around the shaft sunk for the purpose of investigating the cause of the subsidences which had occasioned so much anxiety and interest amongst the inhabitants of the neighbourhood. The first of these subsidences occurred after an unusually heavy fall of rain on April 12th, 1878; but this attracted little attention compared with that caused by two others, which took place in November, 1880.

FIG. 4.

A B C: Subsidences.
C Subsidence examined.

Almost circular openings in the Heath were formed, of a diameter of seven or eight feet, widening bell-shape fashion below, and having a depth of nearly twenty feet. Arrangements had been courteously made to afford every facility to the Geologists by Mr. H. W. Jackson, the Hon. Secretary of the Lewisham and Blackheath Scientific Association, who were trying to explore one of these sinkings.* The probable causes of these subsi-

* The great expense attending the exploration obliged the Lewisham and Blackheath Scientific Association to leave off before any decisive results could be attained. A "Report of the Committee for the Exploration of the Subsidences on Blackheath" was published in 1881, drawn up by Mr. J. K. Laughton, M.A., Chairman. To the Report are appended some "Observa-

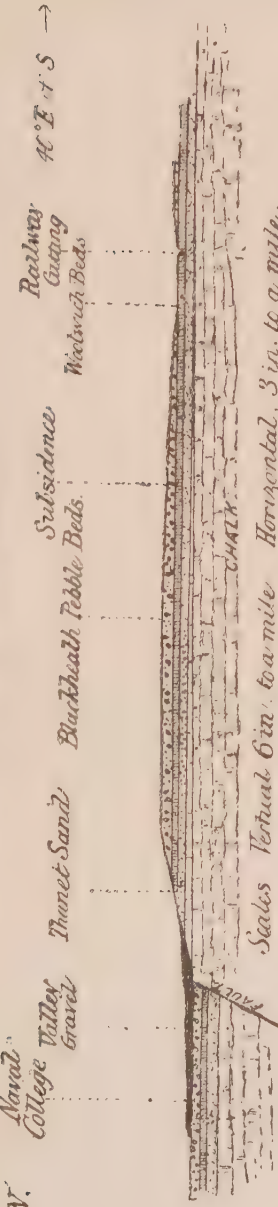


FIG. 5.—SECTION FROM N.W. WING OF R. NAVAL COLLEGE TO S.E. RAILWAY, ABOUT 425 YARDS.

dences were discussed at the pit's mouth by H. W. Jackson, J. Logan Lobley, and T. V. Holmes. Messrs. Jackson and Lobley were inclined to think them due simply to hydro-geological influences, while Mr. Holmes thought these agents unable to produce these results unless aided by the existence of artificial cavities of the Denehole class; as the impervious beds of the Woolwich series would otherwise prevent water that had fallen on the surface of Blackheath from getting lower than the base of the Blackheath Pebble-Beds.

tions by T. V. Holmes, F.G.S.," with a geological section across Greenwich and Blackheath, and diagrams to illustrate the way in which—granting the existence of an artificial chamber in the Chalk, with a narrow shaft leading to it—a hollow would naturally be formed at the base of the Pebble Beds, resulting sooner or later in a subsidence. (See Figs. here reproduced).—(8vo, Blackheath, 30 pp.; see also Geol. Record, 1880-4, i. p. 496).

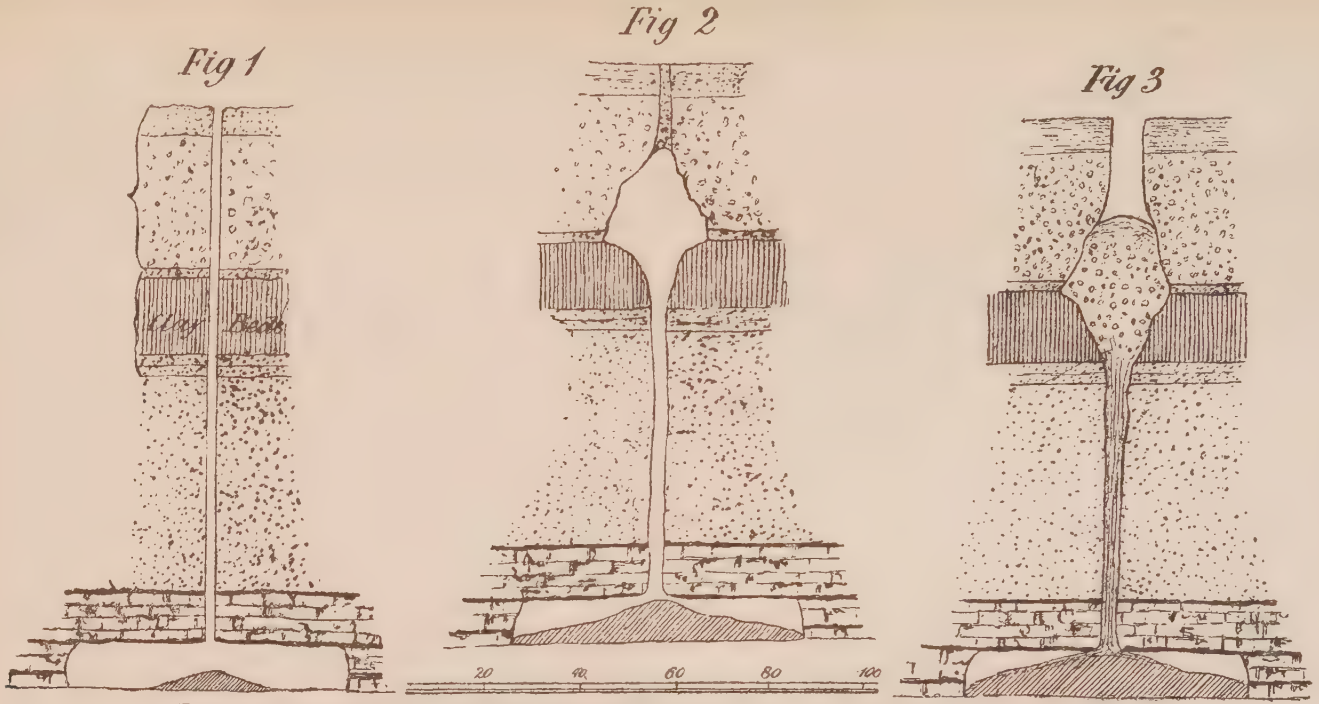


FIG. 6.—DIAGRAMS TO ILLUSTRATE THE HISTORY OF THE BLACKHEATH SUBSIDENCES.

Fig. 1.—Original Denehole, with narrow well-preserved Shaft, passing through Eocene Clays and Sands, and ending in a cavity in the Chalk.

„ 2.—Denehole Shaft, stopped up, erosion of hollow at base of Pebble Beds.

„ 3.—Denehole, after the subsidence (drawn to scale).

WESTCOMBE PARK, GREENWICH, AND LOAMPIT HILL, LEWISHAM.—April 7th, 1883.

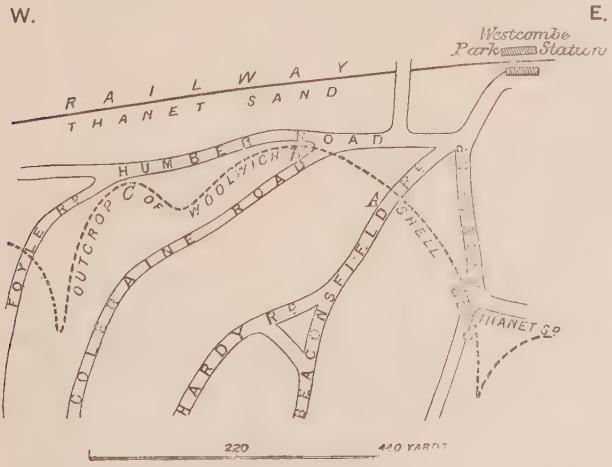
Director—T. V. Holmes, F.G.S.

(*Report by* The Director).

Proc., Vol. viii., *p.* 112.

[The sections at Westcombe Park are described in Proc., vol. viii., 1883, p. 59. The extension of the London and Greenwich Railway to Maze Hill and to Charlton caused the cutting up of Westcombe Park for building purposes. The Lower Tertiary escarpment almost coincides with the northern boundary of Westcombe Park, most of the surface of which consists of the Blackheath Pebble-Beds; the roads then cut across the brow or along the strike of the Tertiary escarpment affording the sections seen. The letters A B and C on the plan (Fig. 7) mark the position of the sections shown in Fig. 8. Perhaps it is better (1888) that all the strata above the shell-beds should be classed as Oldhaven or Blackheath. In 1883 it seemed preferable to group the sand with clayey partings with the Woolwich Series.]

Fig. 7.—Plan of Westcombe Park.

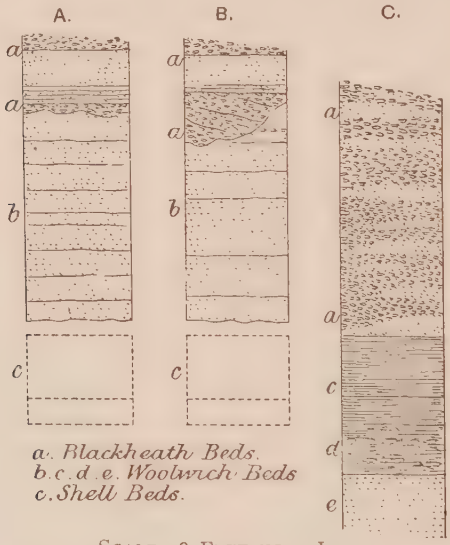


The two chalk-pits a few yards eastward of the station were first visited. The dip of the Chalk, as indicated by the layers of flint, is, in this neighbourhood, slight in amount and southerly in

direction, and the same remark applies to the dip of the overlying Lower Tertiary Beds. A little Thanet Sand, however, is seen overlying the Chalk in either pit.

After leaving the chalk-pits Westcombe Park was entered from its eastern boundary, and its sections viewed in the order in which they are described in Proc., vol. viii., p. 59. Since their

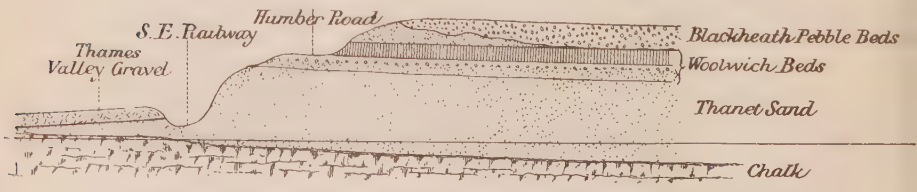
FIG. 8.—SECTIONS IN WESTCOMBE PARK.



SCALE—8 FEET TO 1 INCH.

examination by the Director in November, 1882, they had been cut further back and modified in various ways, the result showing the great variability as regards minute detail of the Woolwich and Blackheath Beds. A word of caution may perhaps be useful

FIG. 9.—HORIZONTAL SECTION IN WESTCOMBE PARK.



on the way in which the Blackheath Pebble Beds mask the beds beneath them along the brow of the Lower Tertiary escarpment.

The pebbles roll down the hillside in vast numbers, and give the impression that it is entirely made up of pebble-beds, where no road or railway-cutting exists to show the true state of things. Thus in a guide-book to Greenwich and its neighbourhood, published in 1882, is a remark about "One Tree Hill" in Greenwich Park, to the effect that "owing to a peculiarity of its geological formation it is composed principally of loose pebbles." One Tree Hill is simply a part of the westerly extension of the Westcombe Park escarpment.

Leaving Westcombe Park by Foyle Road, the party, after leaving Greenwich Park by the Blackheath gate, crossed the Heath, and descended the hill towards Lewisham. On reaching the immediate neighbourhood of the Loampit Hill sections, it became evident that great alterations were in progress there. Much building is going on close to the most easterly pit, that in which the shell-beds of the Woolwich Series and strata immediately below them are displayed. This pit is now enclosed, and used as a store yard. But as it is, fortunately, nearly semicircular in shape, a good view of the strata was obtained from the top of the pit. The oyster-bed, 2 feet thick, separating the two Cyrena-beds, was pointed out and contrasted with the mere trace of an oyster-bed at Westcombe Park. Below the shell-beds and that containing "race" and concretions, a thick pebble-bed was seen; but, above the shell-beds, the thick pebble-beds of Westcombe Park were represented at Loampit Hill by a pebble band of 2 to 3 inches at the base of the London Clay. Fortunately at Loampit Hill on this occasion a new and very clear section of the strata between the Woolwich shell-beds and the London Clay was exposed. They consist, as described by Whitaker (Geol. London, i., 1889, pp. 149, 150), of laminated clay with partings of sand, and sand with partings of clay, having a total thickness of about 25 feet.

[On July 7th, 1888, there was an excursion to *Loampit Hill*, *Lewisham*, and *Westcombe Park*, T. V. Holmes, F.G.S., Director (Proc. Vol. x. p. 501).]

EXCURSION TO PLUMSTEAD AND CROSSNESS.

JULY 5, 1873.

Directors—HENRY WALKER, F.G.S., W. WHITAKER, F.R.S., and FRANK E. HOUGHTON.

(*Report by* H. WALKER.)

(*Proc. Vol.* iii. *p.* 265.)

ON arriving at Abbey Wood the company proceeded across the marshes, a distance of two miles, to the ground occupied by the Metropolitan Main Drainage Works at Crossness, admission having been kindly granted by Mr. J. C. Bazalgette, C.B. By the direction of Mr. Houghton, the marsh had been opened for a depth of eight feet, and in this section the buried land surface was well seen as follows:—

Alluvial Deposit	2 feet.
Yellow Clay	3 ,,
Blue Silty Clay	3 ,,
Peat bed, with stools of trees still rooted	—

The succeeding deposits are thus given by Whitaker (Geol. London, 1889, ii. 66), in the details of the Crossness Well-boring in the same marsh:—

Peat with remains of trees . . .	$6\frac{1}{4}$ feet.
Dark Grey Silty Clay	$1\frac{1}{2}$,,
Thin layers of Peat and Clay, with decayed wood full of phosphate of iron	$1\frac{1}{2}$,,
Dark Grey Silty Clay	$2\frac{1}{2}$,,
Silty Sand	2 ,,
Valley Drift and Oldhaven Beds (?) .	49 ,,
Woolwich Beds	—

Among the stumps and trunks of trees (some of which were of considerable size), the oak and alder were recognised, a catkin of the latter being remarkably well preserved. Mr. Houghton exhibited some articles of furniture made from oak taken out of these marshes during the excavations for the Main Drainage Works.

This forest-bed has a considerable range. From the bed of the river (in which the peat is found by soundings) the forest passes under the marshes of Kent on the one side, and Essex on the other, where it is concealed by the overlying alluvium, and is only revealed by excavations. The same forest was found under the alluvium in excavating the docks in and near the Isle of Dogs, and in excavations in Lambeth and Wandsworth Marshes.

During the excavations in Plumstead Marshes for the Southern Outfall Sewer, in 1862-3, the forest-bed was well exposed.

The Crossness Boring was then visited.

[The details of this boring, as given in the report of this excursion, are necessarily incomplete, but may be seen in full in Whitaker's Geol. London, ii., 1889, pp. 66, 67. As this is one of the deep borings ending in "red-rocks" of Old or New Red Sandstone age, it is thought that the vertical sections of these and other deep borings of S.E. England, given below, will be found useful to those who wish to see their general results at a glance. They are from a Presidential Address to the Essex Field Club, by T. V. Holmes, on "The Subterranean Geology of South-Eastern England" (Essex Naturalist, Vol. ii, Nos. 9 and 10, Sept. and Oct., 1888). The deep boring at Streatham has also ended in rocks of Old or New Red Sandstone age.]

The next visit of the Association to *Plumstead* was paid in 1887 to the Lower Tertiary escarpment, not the marshes. The Director was J. G. Goodchild, F.G.S., and a report was printed in Proc., vol. x., No. 4, p. 191.]

References.

Maps.—Ordnance Survey. Geological, Quarter Sheets, 1 S.W., 1 S.E. 3*s.* each.

New Ordnance Survey. Sheets 270, 271. 1*s.* each.

Stanford's Geological Map of London. 5*s.*

Books.—W. Whitaker, "Geology of London and Part of the Thames Valley." 8vo. *London* (Geol. Survey), 2 vols. 1889. 11*s.* [For literature.]

W. Whitaker, "Guide to the Geology of London." 8vo. *London* (Geol. Survey). 5 Edit. 1889. 1*s.*

FIG. 10.—DEEP BORINGS OF S.E. ENGLAND.

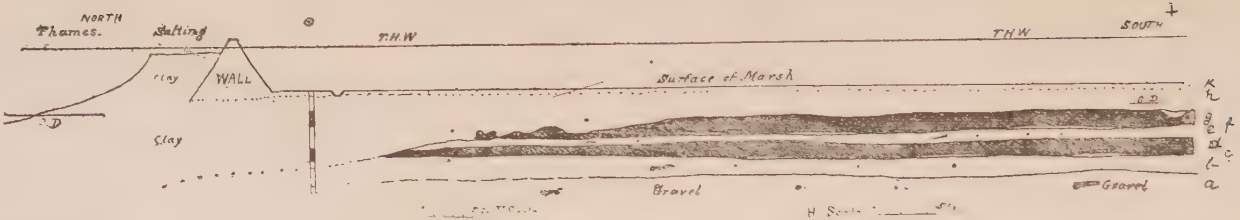
(Thicknesses from H. B. Woodward's Geology of England and Wales.) By permission of the Essex Field Club.

INDEX TO NUMBERS, SHOWING THE RELATIVE AGES OF THE VARIOUS BEDS.

1. Alluvium; made ground, etc.
2. Tertiary Beds.
3. Chalk.
4. Upper Greensand.
5. Gault.
6. Lower Greensand.
7. Purbeck Beds.
8. Portland Beds.
9. Kimeridge Clay.
10. Corallian Beds.
11. Oxford Clay.
12. Great Oolite.
13. Lower Carboniferous Beds.
14. Devonian and Old Red Sandstone.
14*a*. Beds of doubtful age. Old Red or New Red Sandstone.
15. Upper Silurian Beds.

FIG. 11.—SECTION AT CROSSNESS, SHOWING SUPERFICIAL DEPOSITS.

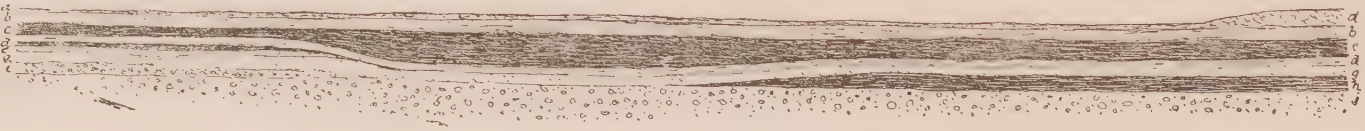
[See Spurrell, Proc., vol. xi., p. 217.]



a. Gravel, becoming sandy on the north. *b*. Sand. *c*. Lenticular thin bed of Sandy Clay, full of fresh-water Shells. *d*. Lower Peat Bed. *e*. Blue Tidal Clay. *f*. Beds of Sand and Shells, as above. *g*. Lower Peat. *h*. Tidal Clay. *k*. Arable Soil, and so-called Brick-Earth. The black marks represent drift-wood. *o*. A Boring, 150 yards west of this point, showing same layers of Peat, etc.

FIG. 12.—SECTION NEARLY ALONG THE WESTERN SIDE OF THE RESERVOIR, SOUTHERN OUTFALL SEWER, CROSSNESS.

[Reprinted from Whitaker, Geol. London, vol. i., by kind permission of the Controller of Her Majesty's Stationery Office.]



Scale (vertical and horizontal)—88 feet = 1 inch.

a. Soil.
b. Brown Silty Clay.
c. Peat.
d. Blue Clay.
e. Peat.
f. Blue Clay.
g. Soft Sand and Clay.
h. Soft Peat and Clay.
} Alluvium.
i. Fine Sandy Gravel.
k. Grey subangular Flint-gravel.
} River Drift.

BELVIDERE, ERITH AND CRAYFORD.

[*Crayford* appears to have been visited in 1869 at the time when no *Proceedings* were published. On May 21st, 1870, another excursion took place, of which there is a brief report in the Proceedings, vol. ii., pp. 34-35.]

EXCURSION TO BELVIDERE.

April 29th, 1871.

Director—Professor J. Morris, F.G.S.

(*Proc. Vol.* ii. *p.* 229.)

The object of this excursion was mainly to afford members of the Association an opportunity of inspecting the fine collection of Mammalian Remains in the possession of F. C. J. Spurrell, F.G.S.

Professor Morris described this interesting collection in his usual happy manner. Almost all the specimens have been obtained from the Pleistocene fluviatile deposits of the immediate neighbourhood of Erith and Crayford. When, therefore, in this Museum there are found remains of three species of elephant, three species of rhinoceros, and species of lion, bear, hyena, horse, and ox, we are forcibly reminded of the abundance of the larger animals, both Carnivora and Herbivora, with which the country surrounding London was peopled in pre-historic times. This collection is interesting, moreover, on account of the evidence it affords of great climatic alternations, for it contains species both of warm and cold climates—the lion of the Tropics and the *Ovibos moschatus* of the Arctic Zone.*

Many species of Mollusca which are now living in England have been found fossil in this locality together with *Corbicula* [*Cyrena*] *fluminalis*, which is not now living in the British area, but is found in the Nile. Additional interest is given to this part of Kent by the existence of numerous caves or excavations in the Chalk. These curious and obscure cavities are locally termed deneholes.

* For a full account of the River Drift of the lower part of the Thames Valley, with the fossil remains found therein, together with a review of the literature of the subject, see Whitaker's "The Geology of London, and of Part of the Thames Valley," 1889, vol. i., pp. 328-453.

EXCURSION TO ERITH AND CRAYFORD.

[*Erith* and *Crayford* were next visited on May 4th, 1872, J. Logan Lobley, F.G.S., being the Director. From his report the following remarks are extracted (Proc., vol. iii. p. 83).]

On arrival at Erith Station the party proceeded to the fine sections of the Thanet Sands, exposed in the great Ballast Pit. This excavation has been formed by the removal of the loamy Thanet Sand, which is used as ballast, and subsequently for iron casting purposes.

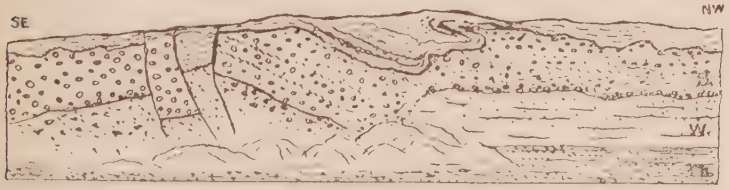


FIG. 13.—WEST SIDE OF THE LARGE BALLAST PIT AT ERITH, 1885.
Pleistocene and Eocene Strata crushed in from the surface, an effect possibly produced by the grounding of large masses of floating ice.
Scale, 25 feet to an inch.

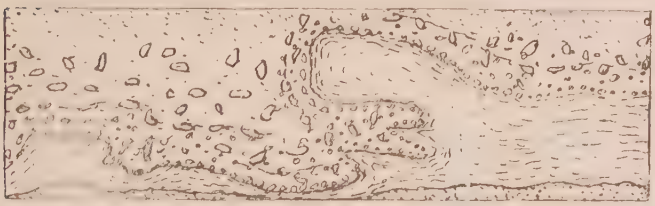
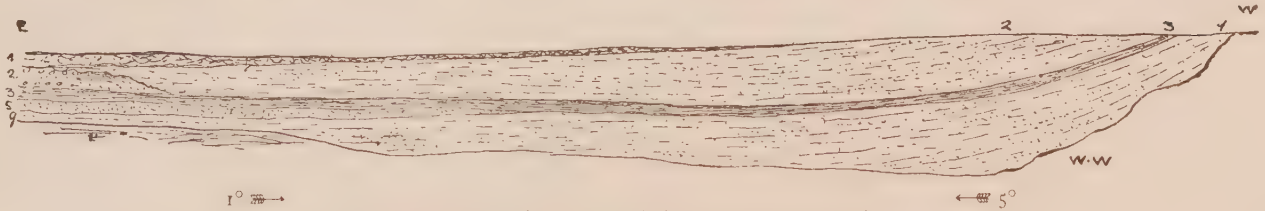


FIG. 14.—EAST SIDE OF THE LARGE BRICK PIT AT ERITH, 1885.
Contorted Beds of Loam, Sand, and Gravel, overlying undisturbed Strata.
Scale, about 10 feet to 1 inch.

FIG. 15.—SOUTH SIDE OF A FOOTPATH LEADING FROM BEXLEY ROAD TO THE LARGE BALLAST PIT AT ERITH, 1885.
Beds of Pleistocene Sand and Loam, kneaded up amongst reconstructed Blackheath Pebble Beds, and overlying undisturbed Woolwich Beds.
Scale, about 10 feet to 1 inch.

FIG. 16. SECTION SHOWN BY THE SOUTHERN FACE OF THE GREAT PIT AT THE ERITH BRICKYARD, 1867.

[Reprinted from Whitaker, Geol. London, vol. i., by permission of the Controller of Her Majesty's Stationery Office.]



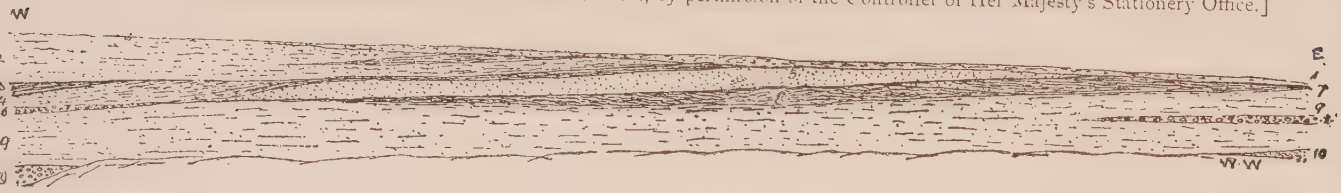
The arrows show the amount of dip at the spots above them.

1. Soil and Wash, lessening westward.
2. Brown Brick-earth, with Race, about 15 feet. Contains Pebbles, and pieces of Shells from the Woolwich Beds.
3. Darker brown Clay, with a little Race, about 5 feet, with a little grey Brick-earth (with Shells) at the bottom, passing down into the Bed below.
5. Sand with Shells (*Cor'bicula fluminalis*, etc.) and Pebbles, about 4 feet; loamy at top in parts, and gravelly at bottom. Thins out as the ground rises westward.
9. Brick-earth, with a little Pebble-gravel.

The numbers correspond with those in Fig. 17.

FIG. 17. · SECTION SHOWN BY THE NORTHERN FACE OF THE GREAT PIT AT THE CRAYFORD BRICKYARD, 1867.

[Reprinted from Whitaker, Geol. London, vol. i., by permission of the Controller of Her Majesty's Stationery Office.]



1. Loamy Soil and Wash.
2. Brick-earth, about 12 feet.
3. Brown Clay, with Race, about 3 feet.
4. Brick-earth, clayey, about 7 feet.
5. False-bedded, light-coloured Sand (the Shell Bed), about 5 feet. *Corbicula fluminalis* very abundant.
6. Pebbly Gravels, about 1 foot.
7. Brown Clay, wedging out against
8. A long, lenticular bed of stiff, grey Clay, with Race, over 4 feet.
9. Brown Brick-earth, with Race, 15 to 20 feet.
10. Sand and Gravel, false-bedded, with blocks of concretionary Sandstone at top, 4 feet shown.

The numbers of the beds are the same as those in Fig. 16.

FIG. 18.—SECTION AT ERITH.

The bottom of the pit is about two feet above the top of the Chalk, which underlies the whole, and is seen at one or two small wells. Wells of little depth in this area furnish water in abundance. The proximity of the Thames, and the slight difference of level between the bottom of the Ballast Pit and high-water mark, cause here an unlimited supply of water in the bed of Chalk immediately underlying the Bull-Head bed, the whole of the Chalk below being filled to saturation. As may be expected, the water falls and rises in these wells with the ebb and flow of the tide in the adjacent river. The sides of the pit reach a height of sixty or seventy feet, and are (1872) formed almost exclusively of the Thanet Sands, the only exception being a small capping of the Woolwich and Reading Series at one place, that at which the side of the pit is highest.

Leaving the Ballast Pit the hill on the south was ascended, and exposures inspected of the Woolwich and Reading Series and of the Oldhaven Beds, which latter consist in this place of a great accumulation of pebbles.

The extensive excavation known as White's Pit was next visited. At this place an interesting section of the old river-bank is capped by a

3. Oldhaven and Blackheath Beds. Flint Pebbles and Sand ; Fossils.
4. Sand and Clay.
5. Clays, sometimes sandy, with estuarine Shells. } Woolwich and
6. Crimson-mottled sandy Clay. } Reading Series.
7. Sand, partly clayey, with Flint Pebbles.
8. Thanet Sand, with green-coated Flints at base.
9. Upper Chalk.

great deposit of Pleistocene sands and brick-earth. The Thanet Sands, which, at the Ballast Pit, about half a mile distant, are sixty feet thick, are here only fifteen; they rest on the Chalk, and form the summit of what was a steep river bank.

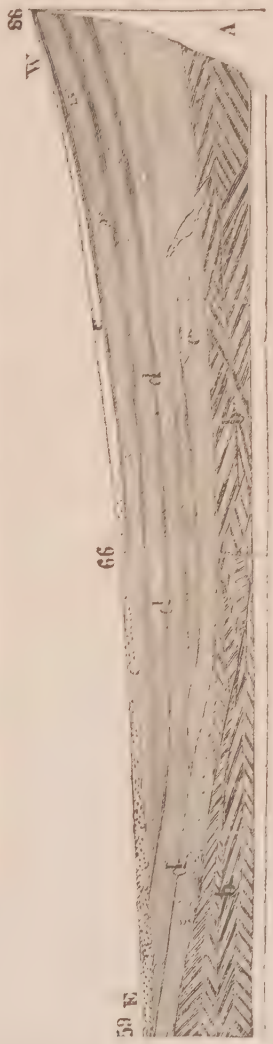


FIG 19.—SECTION OF THE "CORBICULA" PIT, ERITH.

Reprinted, by permission of the Council, from *Quart. Journ. Geol. Soc.*, vol. xxv.

b-e, Beds of River Drift.
A. Chalk.

The Pleistocene deposits yield *Corbicula* [*Cyrena*] *fluminalis*, *Valvata piscinalis*, *Pisidium amnicum*, *Bythinia tentaculata*, &c., and from them have also been derived remains of several

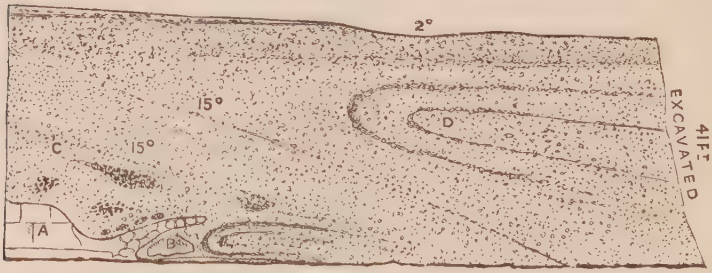
species of Mammalia, including, according to Boyd Dawkins, *Bos primigenius*, *Canis lupus*, *Elephas antiquus*, *E. primigenius*. *Equus fossilis* (= *caballus*), and *Felis spelæa*.

Leaving White's Pit the great excavation at Crayford was reached.

The sections exposed here are very varied, and display some remarkable features of the ancient Chalk river-banks, which have been preserved from destruction or even injury by the enveloping Pleistocene deposits. The fauna is, as might be expected, similar to that of the Erith Pit, but the remains of Mammalia found at Crayford give us a list of species much longer than those from Erith.

FIG. 20.—SECTION IN CRAYFORD PIT.

[Reprinted, by permission of the Council, from the *Quart. Journ. Geol. Soc.*, vol. xxv.]



C. Brick-earth. B. Thanet Sand. A. Chalk.

FIG. 21.—SECTION AT STONEHAM'S PIT, CRAYFORD.

[Reprinted from the *Quart. Journ. Geol. Soc.*, vol. xxiii.]

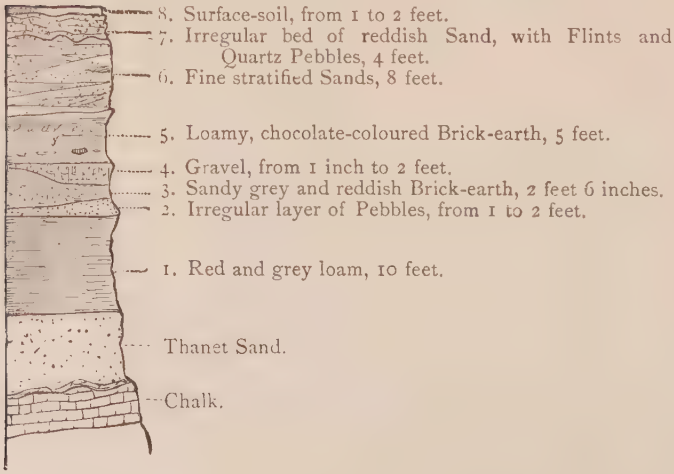
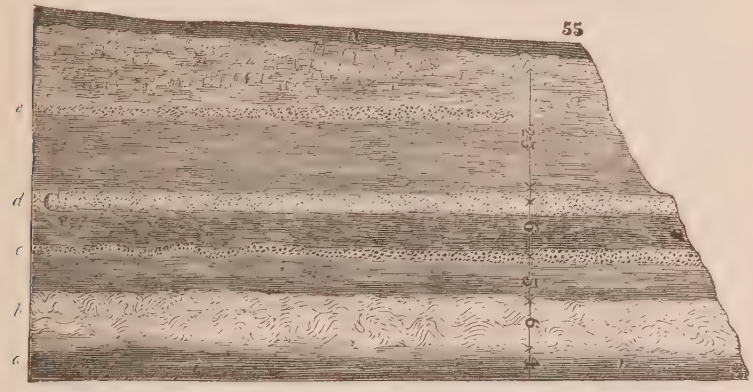
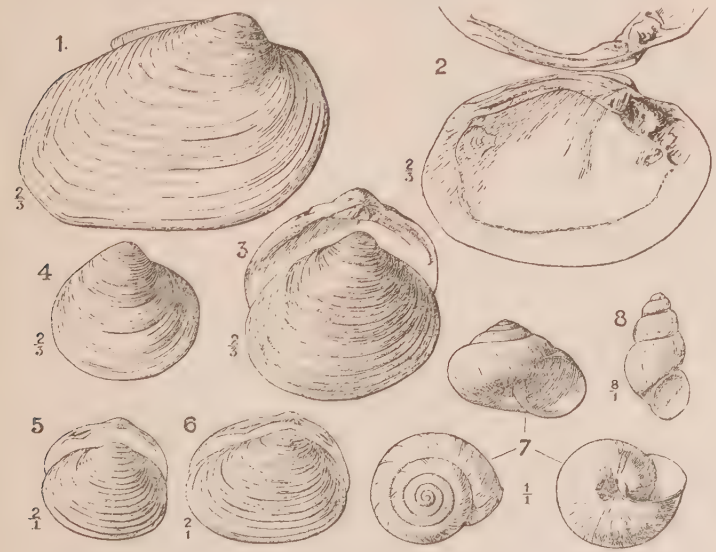

8. Surface-soil, from 1 to 2 feet.
7. Irregular bed of reddish Sand, with Flints and Quartz Pebbles, 4 feet.
6. Fine stratified Sands, 8 feet.
5. Loamy, chocolate-coloured Brick-earth, 5 feet.
4. Gravel, from 1 inch to 2 feet.
3. Sandy grey and reddish Brick-earth, 2 feet 6 inches.
2. Irregular layer of Pebbles, from 1 to 2 feet.
1. Red and grey loam, 10 feet.
Thanet Sand.
Chalk.

FIG. 22.—SECTION OF PART OF THE "CORBICULA" BED, CRAYFORD.
[Reprinted, by permission of the Council, from *Quart. Journ. Geol. Soc.*, vol. xxv.]



e. Laminated Brick-earth, Gravel, and Loam, 25 feet, passing into *Corbicula* Sand-bed.
d. Pebbles from Woolwich Series, Brick-earth and Clay, 6 feet.
c. Brick-earth, 5 feet.
b. Wavy laminated Brick-earth, 6 feet. *a*. Sands, 4 feet.

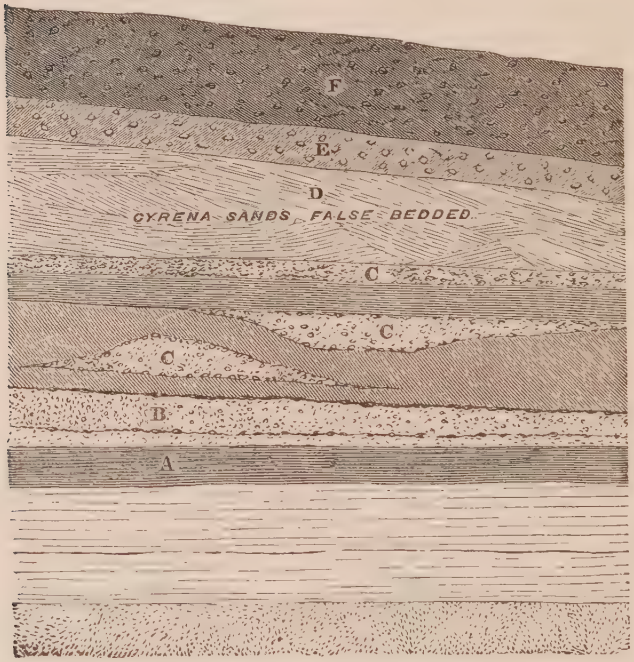
FIG. 23.—NON-MARINE MOLLUSCA, FROM THE RIVER DRIFT (With the exception of 6), extinct in Britain. [Lent by Mr. B. B. Woodward.]



1, 2. Unio littoralis. Erith.
3, 4. Corbicula fluminalis. Crayford.
5. Pisidium astartoides. Crayford.
6. Pisidium amnicum. ,,
7. Helia fruticum Ilford
8. Hydrobia marginata. N.E. London

FIG. 24.—SECTION IN CRAYFORD PIT.

[Reprinted, by permission of the Council, from *Quart. Journ. Geol. Soc.*, vol. xxv.]



Length of Section, 150 feet; Height 30 feet. To show variation in the Pebble Beds C.

F. Covering bed [Trail?] (without Shells).
D. False-bedded Sand *corbicula*-bed, from 4 to 6 feet.
B, C, and E. Beds with Shells.
A. [Not defined.]

[Excursions to *Erith* and *Crayford* were made on June 26th, 1875 (J. Logan Lobley again acting as Director), and on April 6th, 1879, under the leadership of Prof. J. Morris. The reports of both are extremely brief, and contain nothing new. They may be found in Proc. Geol. Assoc., vol. iv., p. 323, and vol. vi., p. 174. On June 13th, 1885, the *Erith* and *Crayford* pits were again visited, F. C. J. Spurrell directing. A full report of this excursion is given in Proc., vol. ix., pp. 213-16, by F. C. J. Spurrell and J. G. Goodchild, with a section of a cliff near Crayford (Fig. 25), and references to writers on the formations seen in this neighbourhood. The latest visit of the

Association to Crayford was on May 3rd, 1890, the Directors being F. C. J. Spurrell and E. T. Newton.

On Saturday, May 17th, 1890, there was an excursion to *Swanscombe* under the direction of F. C J. Spurrell. The party alighted at *Northfleet* and returned from *Greenhithe*.

Near *Crayford*, but a little higher up the the valley of the Cray, is *Bexley*. The most important sections visible in this neighbourhood are those seen during descents of the deneholes, which abound in Jorden's Wood.]

FIG. 25.—SECTION OF CLIFF NEAR CRAYFORD.

a, Chalk. *b*. Flints. *c*. Layer of chipped Flints. *d*. Brick-earth, *xx*. Bones of Rhinoceros.

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MAPS.—Ordnance Survey. Geological, Sheet 1 S.W. 3*s*.
New Ordnance Survey. Sheet 271. 1*s*.

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EXCURSION TO THE DENEHOLES OF BEXLEY.

JUNE 24TH, 1882.

Directors—F. C. J. SPURRELL, F.G.S., and T. V. HOLMES, F.G.S.

(*Report by* T. V. HOLMES).

(*Proc.*, *Vol.* vii. *p.* 400.)

ON reaching Bexley the party proceeded to Stankey Wood, on the east side of Baldwyns, the proprietor of which, Mr. J. G. Hepburn, had kindly given permission for the descent into one of the pits.

The word Deneholes is old English ; it signifies *den*holes, and is pronounced *da*neholes. Though mentioned by Camden, Lambarde, and Hasted, Deneholes have been strangely neglected in the present century. They are, therefore, little known, though almost all geologists and anthropologists know more or less about pits of the Grimes' Graves and Cissbury class. Deneholes, indeed, owe the slight notoriety they have recently acquired to various paragraphs in the *Times* and other newspapers, in which they were alluded to as a possible cause of the subsidences at Blackheath (*v. p.*); and, on the other hand, to the reading of Mr. Spurrell's paper (*Archæol. Journal*, 1881, Nos. 152 and 153), and to the Report of the Blackheath Subsidence Committee (*Blackheath*, 1881). Consequently this year the Bexley Deneholes have been visited both by the Geologists' Association and by the Lewisham and Blackheath Scientific Association, while those at Hangman's Wood, near Grays, north of the Thames, have twice been the scene of an excursion of the Essex Field Club.

Denehole shafts are of very various depths, and the caverns, at their base, vary much in size and in plan. The shafts are from 2 feet 6 inches to 3 feet in diameter, where they have suffered but little from the weather, and are perfectly cylindrical in shape. They especially abound in the neighbourhood of Bexley and Crayford in Kent, and between Purfleet and East Tilbury in Essex. In Stankey Wood, and at Cavey Spring, near Bexley, great numbers are concentrated in two or three acres of ground, while single pits are scattered here and there in addition. The majority are, however, not now open, their position being indicated by basin-shaped depressions varying in depth from 5 feet to 15 feet or more.

The descent into the cavern being slow and gentle allowed the visitor to notice the narrowness of the shaft and the presence of the footholes in its sides, by means of which its original excavators had ascended and descended. So little enlarged is the shaft in the selected Denehole (No. 2, in Pl. II. of Mr. Spurrell's paper) that, on the occasion of the visit of the Lewisham and Blackheath Scientific Association, two of the visitors ascended about 20 feet, and descended again by means of these footholes. The upper 40 feet of this shaft is in Thanet Sand, the rest being in Chalk. Its sides are coated by moss, which has tended most efficiently to prevent denudation. At the bottom of each Denehole-shaft is a conical heap of sand and *debris*, with occasionally the skull or bones of some unfortunate dog or sheep which has fallen down the shaft and perished. The marks made by the claws of dogs, which have vainly tried to get out by climbing the sides of the caverns, were abundantly visible in this one up to a certain height.

Though the shaft of the selected Denehole was, as we have seen, in excellent preservation, the cavern itself had suffered much from downfalls of Chalk and Thanet Sand from the roof. These tended much at first sight to obscure its plan, which became evident only by degrees. The shaft entered the centre of the chamber, and admission to it was given by means of two openings in opposite sides of the shaft, the Chalk at right angles to the direction of these openings being left in the form of two pillars supporting the roof. The cavern would at first consist of two chambers in the same straight line, the result of the enlargement and prolongation of these openings. Then chambers at right angles to them would be added at similar distances from the shaft and on each side of it. The cavern would then be six-chambered. And by increasing the breadth of these chambers, except just at their mouths, the partitions between them would disappear, six pillars between their former entrances remaining. This would have been the final state of the Denehole descended, but that its original excavators, having apparently needed increased and undivided space, removed the two pillars on one side of the shaft, and caused the downfall already mentioned. The downfall was, possibly, to some extent, due also to the thinness of the chalk roof, which was only about 2 feet 6 inches thick. The dome, mainly in Thanet Sand, resulting from the downfall in this part of the cave, is so beautifully regular in shape as to look at first sight like a work of design. The greatest diameters of this

cavern were found by Mr. Spurrell to be 49 by 38 feet, and the height about 25 feet.

The shafts in Stankey and Cavey Spring are all mainly in Thanet Sand, capped, at the former place, by two or three feet of Dartford-Heath Gravel. It is evident that these Bexley Deneholes differ from pits of the Grimes' Graves class, and from those at Cissbury, in many fundamental particulars. The shafts at the last-named places are large in diameter, and broader at the top than at the bottom, whence low galleries 3 feet to 5 feet high, or thereabouts, proceed in various directions, along the line of a particular flint band, and connect the various shafts. The Deneholes, on the contrary, have narrow cylindrical shafts of very small diameter, terminating in lofty chambers about 15 to 25 feet high, which never communicate with adjoining caverns, though they are often very close together. The nearest cavern to No. 2, Stankey, for example, is only separated from it by a thickness of about 10 feet of Chalk, yet no attempt has been made to unite them. And, as regards geological position, shafts of the Grimes' Graves class are wholly, or almost wholly, in Chalk, while these Bexley Deneholes are concentrated in spots where there are from 40 to 60 feet of overlying beds above the Chalk. Yet there is a broad expanse of bare Chalk less than a mile eastward of Stankey and Cavey Spring.

After the visit to the cavern, Mr. Spurrell led the way to Jorden's Wood, a few hundred yards away, in which there are ancient entrenchments and other works, marking the site of an ancient village. A square camp, Roman in plan, and in which coarse Romano-British pottery has been discovered, was shown to have been placed over earlier works belonging to this village, the pre-existence of which has somewhat modified the shape of the camp. Denehole shafts were seen here and there in the wood. Many flint flakes and implements have been found from time to time in this wood and the neighbourhood generally. This camp and the works close to it are on Thanet Sand.

The party then proceeded across Dartford Heath to Dartford, passing by the way some excavations for Dartford-Heath Gravel and a Chalk-pit.

References.

Maps.—Ordnance Survey. Geological. Sheet 1. 3*s*.
New Ordnance Survey. Sheet 271. 1*s*.
Stanford's Geol. London. 5*s*.

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BROMLEY AND CHISELHURST.

[The first visit to the above places was on June 18th, 1864, and is reported, Proc., Vol. i. p. 404, by A. Ramsay, junr. The next was on June 15th, 1872. On this occasion the Directors were James W. Ilott and Coles Child. After inspecting the Sundridge Park and other sections the party proceeded to the caves in the Chalk under Camden Park, which had been illuminated by Mr. Strode, the owner of the estate. The brief report of this excursion may be read, Proc., vol. iii. p. 114. Another excursion took place on April 22nd, 1876, J. L. Lobley being Director, and a full account follows.]

EXCURSION TO BROMLEY, SUNDRIDGE, AND CHISELHURST.—April 22nd, 1876.

Director—J. Logan Lobley, F.G.S.

(Report by the Director.)

(*Proc. Vol.* iv. *p.* 498.)

A large area in the neighbourhood of Bromley is occupied by the Shell-beds and the overlying Sands and Pebble-beds of the Woolwich and Blackheath Beds, and good sections of these beds are exposed along the railway near Bromley Station. In the cutting to the east of the station the Shell-beds of the Woolwich and Reading Series are inclined at a low angle to the west. The characteristic *Cyrena cuneiformis* occurs here in great abundance, associated with *Ostrea*. At the western end of this cutting the Sands form the upper beds exposed.]

The Pebble-beds are well seen immediately behind the railway station, by the side of the inclined road which has been cut through them. These remarkable beds, an accumulation of shingle, are, with the underlying sands, the equivalents in the western part of Kent of the beds exposed at Oldhaven Gap, near the Reculvers, and called by Whitaker the "Oldhaven Beds." They consist of smooth, oval, black flint pebbles, with, in some places, a considerable quantity of intermingled sand, and in others a matrix of carbonate of lime which cements the pebbles together, forming a conglomeratic rock; and in other localities, as at Blackheath, the pebbles are almost devoid of any intermingled material. As has been pointed out by Whitaker, the entire absence of subangular or little-worn pebbles indicates that this vast bed of worn Chalk flints was not a shore accumulation of shingle at the foot of a Chalk cliff, like that now forming the

beach at Brighton, but was doubtless a shoal or bank considerably removed from the shore line, which pebbles would only reach after much rolling and consequent wear. The bed of quartzose sand, found underlying the Pebble-beds, Whitaker considers ought to be associated with them, and not with the Woolwich Beds. The sand has here a most irregular upper boundary, the Pebble-beds entering it in wedge-like or teeth-like masses to a considerable depth. This section shows a remarkable instance of current-bedding, the oval pebbles lying with their longer axes horizontal, while, as has been pointed out by Whitaker, lines of bedding, inclined at an angle of 25°, are very distinct. This is, perhaps, even better seen at a new section of the same beds on the opposite side of the railway, which was next inspected.

A walk through the village of Bromley brought the party to the grounds of Bromley Palace, the residence of the late Mr. Coles Child. A small section of the Woolwich Beds here, where not masked by overgrowth, shows a *Cyrena*-bed distinctly separated by a stratum of clay from an *Ostrea*-bed. Springs of highly ferruginous water are seen in one or two places in the grounds, and an ancient bath-house attests the value set upon this water in past times.

After walking through the beautiful grounds of Bromley Palace, in which are some of the largest evergreens in the neighbourhood of London, the party proceeded by the path across the fields to Widmore Kiln. The section at Widmore is figured in the "Geology of the London Basin," 1872, p. 246 (1889, i. p. 221), and on p. 247 is described as follows :—

		Feet.
	Soil.	
London Clay.	Grey and brown weathered Clay, at most .	3½
	Basement bed : Clayey Pebble-bed, the pebbles of black flint	½ to ½
Oldhaven Beds	—Light-coloured (mostly nearly white) sand, with a few pebbles in the upper part, chiefly in one broken line, and a few thin clay-layers; below 8 feet from the top of these last are in force	12 or more.
Oldhaven (or Woolwich) Beds ?	Dark bluish-grey clay, laminated, with a few very thin sandy layers, small pieces of leaves, wood (in the state of lignite) and iron pyrites . . . . about	9
	Sand, with layers of clay in fine alternations. At one part (in the trough) the top highly ferruginous; at another it seems to pass up into the clay, the lower part of which is then more sandy. Tabular concretionary masses of sandstone occur a few feet down, and still lower many good impressions of leaves have been found. Not bottomed	26 or more.

The "dark bluish-grey clay" is probably peculiar to this section, Whitaker stating that he is unaware of any other place at which it is seen. A collection of well-preserved specimens of leaves from the Widmore Beds was in the possession of Mr. Coles Child in 1872, but now plant remains are rarely found. The President, W. Carruthers, F.R.S., determined the leaves found to belong to the sub-tropical *Ficus* and *Cinamomum*, genera, it is worthy of remark, not represented in the London Clay of Sheppey, which contains a large flora of a tropical and sub-tropical character.

The various beds having been pointed out and described, the way was led to the eastern extremity of Sundridge Park, in which is situate the "Rock-pit," so well-known to geologists. The Sundridge "rock" is a conglomerate of shells and smooth oval flint pebbles, embedded in a calcareous matrix, and affords rough building-stones well adapted for rustic buildings, to which its variegated surface adds picturesqueness, as is exemplified by the Chiselhurst Lodge of Sundridge Park. In a very short time *Ostrea pulchra*, *Pectunculus Plumsteadiensis*, *Cyrena cuneiformis*, *C. deperdita*, *Cerithium funatum*, and *Melania inquinata* were found.

At no great distance to the east of Sundridge Park a section shows Chalk with overlying Thanet Sands, thus revealing the Chalk "inlier," which extends from west to east for upwards of three miles, surrounded by the Lower Eocene. Of this inlier, Whitaker writes at p. 65 of "The Geology of the London Basin, 1872,"—"The valley that runs through Sundridge, Camden, and Bickley Parks, between Bromley and Chiselhurst, lays bare an outcrop of this formation (Thanet Sands), and the Chalk, in the form of an inlier, that is to say, surrounded on all sides by a higher formation. This exposure of the Thanet Sands, within the area of the overlying Woolwich Beds, and at so high a level, is owing to a slight upheaval of the beds, which has brought the lower formation within reach of the common forces of denudation; the outcrop extends from the north-western part of Sundridge Park, through Camden and Bickley Parks."

The line of the railway was then crossed, and on its northern side an exposure of Thanet Sands, Woolwich Beds, and Oldhaven Beds was found in a recently formed road. The section having a sloping face, the pebbles which have rolled down from the uppermost bed cover a considerable portion of the surface, and thus the Pebble-bed appears to be much thicker than it is, and the Sands correspondingly less important than is really the case.

Still going eastward the party were conducted to the entrance to the Chalk Caves of Camden Park.* Lower beds are exposed here, the Chalk being seen to a depth of from 15 to 16 feet. The usual bed of green-coated flint separates the Chalk from the Thanet Sands above, which extend to the soil at the top of the section. The Chalk at this place, obviously the uppermost bed of the Chalk of West Kent, appears to be harder and more compact than the similar bed at other sections. One bed, not much below the top, is so continuous and compact that it forms an immense unjointed slab, constituting a continuous roof to the caves, or rather galleries, which extend for a long distance under Camden Park. These galleries, driven under ground for quarrying purposes, consist of longitudinal and transverse workings, leaving great masses as pillars for the support of the roof. Sponges are more than usually abundant in the Chalk of this place, and some good specimens were obtained on this occasion.

In the work by Charles Barrois, "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande" (1876), the various beds named in the classification of the Chalk of this part of England by another of our Associates, Mr. Caleb Evans,† have been correlated with the divisions of the Chalk generally which M. Barrois seeks to establish. This correlation is given at page 139 as follows ‡ :—

Classification of the Chalk of the South-East of England, by Caleb Evans.	General Classification of the Chalk, by C. Barrois.
	Assise à Belemnitelles.
Purley Beds.	Zone à Marsupites.
Upper Kenley Beds.	Zone à Micraster cor-anguinum.
	Zone à M. cor-testudinarium.
Lower Kenley Beds.	Zone à Holaster planus.
Whiteleaf Beds.	Zone à Terebratulina gracilis.
Upper Marden-Park Beds.	Zone à Inoceramus labiatus.
Lower Marden-Park Beds.	Zone à Belemnites plenus.
	Zone à Holaster subglobosus.
	Chloritic Marl.

* Figured in Whitaker, Geol. London, i, 1889, p. 116.

† "On Some Sections of the Chalk between Croydon and Oxted," by Caleb Evans, 8vo, London (Geol. Assoc.), 1870.

‡ See also J. Morris, "The Chalk: Its Distribution and Sub-Divisions" Proc. Geol. Assoc., vol. viii. (1883), p. 208.

It will thus be seen that M. Barrois considers the highest Chalk in this part of England to be the second of his divisions, "Zone à Marsupites;" and at page 138 we find he states—"C'est dans cette région (Kent) que les zones à *Holaster subglobosus* et *Belemnites plenus* acquièrent leur plus complet développement. La zone à Belemnitelles n'est pas connue dans cette partie de l'Angleterre."

Exposures of all the beds, from the Upper Chalk to the London Clay, had been seen. It remained to ascend to the high ground of Camden Park, which affords extensive views over the district, and a good standpoint from which to note the physical features of this part of Kent.

References.

Maps.—Ordnance Survey. Geological—Sheet 6. 8*s* 6*d*.
New Ordnance Survey—Sheet 271. 1*s*.
Stanford's Geol. London. 5*s*.
Book.—Whitaker, Geol. London, 1889. 2 vols. 11*s*.

EXCURSION TO ST MARY'S CRAY, WELL HILL, AND SHOREHAM, KENT.—Saturday, June 26th, 1874.

Director—Professor J. Prestwich, F.R.S.

(*Report by* Henry Walker, F.G.S.)

(*Proc. Vol.* iv. *p.* 155.)

On arriving at St. Mary's Cray, the party inspected the cutting at the Station, which exposes lower pebbly beds of the Woolwich and Reading Series and Thanet Sands. The valley-deposits, close to the Gas Works, were then visited. These were found to consist of ten or twelve feet of fine loamy brick-earth, with land-shells, and a little gravel; the whole having a "rain-wash" aspect. The Chalk was seen below. Professor McKenny Hughes gave a lecture on the physical history of the landscape of which this valley is one of the features, and then a start was made for Skid Hill, where Prof. Prestwich was to meet the Members, and act as Conductor for the day. Walking from St. Mary's Cray, Kevington, East Hall, and Skid Hill, the last named signalised by two grand trees of Portugal laurel (*Cerasus Lusitanica*), were successively reached.

The physical and topographical features immediately westward were first explained, Keston, Knockholt Beeches, and the long dry valley of the upper Cray being notable objects in the

view. Skid Hill itself (capped with gravel) is but a portion of the interesting outlier of Thanet Sands and Woolwich Clay which at Well Hill—a mile further along the same elevation—has a still larger capping of gravel, of great age and singular interest. At length the higher ground, more than 600 feet above Ordnance Datum, was reached, and the Well-Hill gravel sections confronted the visitors. Here, above the Thanet Sands and the Woolwich Beds, were large rolled flints, highly fossiliferous, in a reddish, unstratified sandy matrix. A closer search discovered fragments of chert and ragstone. These Prof. Prestwich referred to the Lower Greensand beds at the Sevenoaks Rangé, some six miles further south, and sedarated from Well Hill by the deep and broad vale of Holmesdale. The Well Hill gravel, according to Prestwich, is a solitary patch of marine gravel, of Glacial age, which once stretched over Kent, and is altogether an unique geological monument in the county. Before leaving the spot the following orchids were gathered on the damp parts of the heath about Well Hill—*Orchis maculata*, *Habenaria bifolia*, and *Listera ovata*, and close at hand under the trees *Ophrys muscifera*.

The following objects, to which Prof. Prestwich called attention on the arrival at Shoreham may also be mentioned:—Some notable sand-pipes in the Chalk, by the side of the high road to Sevenoaks, between the eighteenth and nineteenth milestones; a very fossiliferous bed of Chalk with *Inoceramus*, near the first shaft at the north entrance to Halstead Tunnel; and a dry upper valley of the Chalk (south branch of the Timberden valley) with six feet thickness or more of flints, the water standing at a level below the valley fully 100 feet deeper than it once stood. Lastly, the visitors viewed from the hill near Darent Holme, the trumpet-mouthed valley of the Darent, opening out into the Weald, but draining in the opposite direction into the Thames.

References.

Maps.—Ordnance Survey. Geological—Sheet 6. 8*s*. 6*d*.
New Ordnance Survey—Sheet 271. 1*s*.
Book.—Whitaker, Geol. London. 1889. 2 vols. 11*s*.

[The five excursions which follow were arranged for the purpose of enabling the members of the Association to make themselves acquainted with the Physiography and the Geology of the country between the London Tertiary Basin and the summit of the Weald.]

EXCURSION TO ORPINGTON AND KNOCKHOLT.

SATURDAY, MAY 10TH, 1879.

(First of the Weald Series).

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by*—W. FAWCETT, B.Sc.)

(*Proc. Vol.* vi. *p.* 189).

AT Orpington, on the edge of the London Tertiary Basin, just outside the station, Mr. Lobley pointed out an exposure of Thanet Sands, the lowest member of the English Tertiaries, and, at a little distance, a good section of the Chalk, the uppermost of the English Secondaries. The presence of Chalk is clearly indicated by the altered character of the country from this point to Knockholt. The bottoms of the Chalk valleys are here covered by ten or twelve feet of gravel and wash of Pleistocene age, seen on this occasion in an excavation for new wells for the Kent Water Company close to the railway bridge. The road now runs along the bottom of the valley which is but a continuation inland of that of the Cray, but streamless from the absorbent character of the Chalk.

Arriving at Green Street Green, a fine section of Valley Gravels was pointed out, showing an increased thickness of this deposit, fully twenty feet being here exposed. After passing through the village, the ascent of the Downs was commenced, and the party speedily reached higher ground commanding a view over a large area. Mr. Lobley remarked that, instead of the ordinary appearance of sheep-walks in a Chalk country, we here meet with woods and cultivated fields. This is due to the presence of superficial deposits of clays and gravels, the remains of the Tertiary beds once covering the Chalk. After passing High Elms, the road led over the upland towards Cudham. On the right is a beautiful example of a Chalk valley, with its steeply sloping sides and streamless bottom.

From Cudham the Downs were crossed, by Lutt's Green, to Knockholt village. From Knockholt Beeches, 783 feet, there is a most extensive view. Looking towards London, the Crystal Palace was visible on the high ground of the London Clay; to the south-east, the range of Lower Greensand hills on which Sevenoaks is built; and, further on, the hills of Hastings Sands.

EXCURSION TO KNOCKHOLT AND SEVENOAKS.

SATURDAY, MAY 24TH, 1879.

(Second of the Weald Series).

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by*—W. FAWCETT, B.Sc.)

(*Proc. Vol.* vi. *p.* 194).

STARTING from Halstead Station, the route lay through Halstead Place Park, by Knockholt Beeches, through Chevening Park, Chevening, Chipstead, Riverhead, and Sevenoaks. At Halstead Mr. Lobley showed how much more complete had been the denudation than about Cudham; here there is but little soil, or valley gravel. The Chalk has bands of flints, characterising it as Upper Chalk.

From Knockholt Beeches there is an easy descent through the woods of Chevening Park, down the Chalk escarpment.

At Chipstead Tile-yard, Pleistocene Brick-earths are seen overlying the Gault clay. They are both worked and often mixed. Here in the Gault are found *Ammonites interruptus*, *A. auritus*, *A. lautus*, *Belemnites minimus*, and *Inoceramus concentricus*; but *Am. splendens* was not seen, though it is a characteristic fossil of the Gault elsewhere. From the blue Gault clay are made red bricks and dark tiles. The redness is due to the peroxidation of the iron of the clay by the burning, and the dark colour is produced by the oxide of manganese being mixed with the clay. Iron compounds are plentiful in the Upper and Lower Greensand and Gault, chiefly in the form of sulphuret or iron-pyrites, but not in the Chalk. From the tile-yard the way lay across the bottom of the valley, and over the infant Darent to Chipstead village, where the Lower Greensand, which forms the hilly and beautiful ground to the south, begins to rise and form the southern side of the valley. In half-a-mile the village of Riverhead is reached.

At Riverhead the Folkestone Beds of the Lower Greensand (of a foxy-brown colour) are exposed; but they are better seen in the quarry at the Bat and Ball Station, Sevenoaks. In this latter place the sand is loose, the grains only being cemented together here and there in thin irregular layers of ferruginous sandstone. These layers at first sight give the appearance of false bedding, but Mr. Lobley was of opinion that they were not due to that cause. He pointed out the "Box-stones," large irregular ferruginous

concretions, or rather shells with loose light-coloured sand in the middle, many of them being of very considerable size. They are very dark in colour, and so hard that they are used for road-metal.

[On June 1st, 1889, some gravels at and near *Ightham* were visited, Prof. Prestwich and W. Topley being directors. See *Proc.*, vol. xi., p. lxvi.; and Prestwich, *Quart. Journ. Geol. Soc.*, vol. xlv. (1889), p. 270.]

EXCURSION TO SEVENOAKS AND TONBRIDGE.—

SATURDAY, JUNE 14TH, 1879.*

(Third of the Weald Series).

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by* W. FAWCETT, B.Sc.)

(*Proc. Vol.* vi. *p.* 202).

MEMBERS left the train at Dunton Green to inspect the excavations in the extensive Brick-yards of Mr. W. J. Hooker, who courteously gave every facility for the observation of the sections and the collection of fossils. These excavations well show the Gault; it extends E. and W. for many miles along the base of the escarpment of the North Downs, forming the beautiful Vale of Westerham. Both the Gault and the Pleistocene Brick-earths which cover the Gault in places along the valley, afford here materials for bricks and tiles.

After crossing the alluvium of the Darent Valley, and the stream itself, the Folkestone Beds of the Lower Greensand were found exposed in a field near Riverhead, through which village the party then proceeded to the Tubs Hill (Sevenoaks) Station. Between the station and the tunnel there is a fine section, about 90ft. high, showing the Hythe Beds of the Lower Greensand, and yielding abundance of *Gryphæa sinuata*. F. Drew, in Topley, (*Geology of the Weald*, p. 116), gives the following description of the beds on the coast of Kent:—"The Hythe beds are interstratifi-

* Sevenoaks was also visited by the Association in 1864 and 1866. In *Proc.* vol. i., p. 390, about a dozen lines are given by Caleb Evans to the details of the excursion of 1864, followed by a paper on the Geology of the district The excursion was especially undertaken to inspect the Geology of the extensive railway-works carried on by the South-Eastern Railway at that time, and the paper may be consulted with advantage. The excursion of 1866 took place while no Proceedings were published.

cations in about equal proportions of limestone and sand. The former is close in texture, has a grayish blue colour, and contains fine grains of quartz; the latter is for the most part drab-coloured, impure, rather clayey, and somewhat calcareous; the stone goes by the name of 'rag,' while the intermediate sandy beds are called 'hassock.'" At Sevenoaks the distinction is not so great; the hassock is harder, is in a larger proportion than the rag, and both are used for building. The Sandgate Beds, intermediate between the Folkestone and Hythe Beds, are here wanting, whereas at Folkestone all three are developed. A good example of a fault, and a remarkable anticlinal, were noted near the entrance to the tunnel. The Folkestone Beds cover the Hythe Beds, and form the high ground on which the town of Sevenoaks stands. The junction was seen as the party ascended from the railway cutting and made their way to Sevenoaks. A brief visit was paid to Knole Park, in which the beautiful country formed by the Lower Greensand of Kent is well shown.

Proceeding along the road to River Hill, on the escarpment of the Lower Greensand, a fine view over the second of the great east and west valleys was obtained. At the bottom of the hill is the Atherfield Clay, then the broad expanse of Weald Clay, with the Medway meandering through it. The road through Hildenborough was taken, and after a brisk walk across the Weald Clay vale, rich with hop-gardens and orchards, Tonbridge was reached, standing close to the Alluvium of the Medway.

EXCURSION TO TONBRIDGE AND TUNBRIDGE WELLS.—Saturday, June 28th, 1879.

(Fourth of the Weald Series.)

Director—J. Logan Lobley, F.G.S.

(*Report by* W. Fawcett, B.Sc.)

(*Proc. Vol.* vi. *p.* 204.)

The members of the Association met at Tonbridge to inspect the country from Tonbridge to Tunbridge Wells.

Tonbridge Station is on the Tunbridge Wells Sand; and at the Hastings Road is first seen the Wadhurst Clay, which extends to Quarry Hill. The Ashdown Sand at Quarry Hill, thrown up by a fault, is interesting, as it is the lowest member of the Wealden group. A short distance after passing Mabledon Lodge

we again come upon the Wadhurst Clay, succeeded at the Penshurst Road by the Tunbridge Wells Sand, which extends beyond Tunbridge Wells, with outliers here and there of the Weald Clay. At one of those points on the road from which a view may be had of the valley of the Medway, Prof. Morris spoke of the origin of the Medway Gravels. These gravels occur at various heights above the present bed of the river, up to as high as 300 feet. It is remarkable that in no part of the Weald are gravels found at any great distance from the margins of streams ; and hence it is inferred that they have been laid down by rivers actually running in the same courses as at present. The gravels along the upper stream of the Medway consist only of Wealden pebbles ; but, on the banks of the Eden, the western tributary of the Medway, they also contain flints and flint pebbles from Tertiary Beds. The Eden joins the Medway at Penshurst ; from that point, onwards, the gravels combine the characters of the Upper Medway Gravels and the Eden Gravels, until the Medway has passed well out of the Weald country, and then the Wealden pebbles disappear. Again, the gravels of the Beult and Teise, the eastern tributaries, joining the Medway at Yalding, are composed of Wealden pebbles. Now when it is seen that the Upper Medway, the Beult, and Teise, and their feeders, drain Hastings Beds, and that the Eden runs down from the Chalk escarpment, it appears difficult to explain the composition of the gravels on any other hypothesis than that adopted by the Geological Survey, that the gravels were formed by rivers running in the same courses, and (contrary to the theory of S. V. Wood, junr.*) *in the same direction* as at present. One difficulty at first sight is that the Wealden pebbles disappear in gravels near the mouth of the Medway ; but this is explained if the *débris* of the Wealden Beds, either entirely disappear almost as soon as formed, as in the case of the calcareous "Rag," or are of a character so soft in comparison with flints and Tertiary pebbles, that they soon wear down from pebbles into sand. There appears, then, to be proof that rivers have excavated valleys to the depth of at least 300 feet. It is impossible to say how much more river-erosion had taken place before these highest gravels were deposited ; but, if it was as much as 300 feet, that amount would account for the whole of the subsequent denudation of the original plain of marine denudation—that is to say, all the present features of the

* Quart. Journ. Geol. Soc., vol. xxvii., 1871, pp. 3-27.

country, the hills and valleys, are due to the action of rain and rivers only. Certainly there is no evidence of any other agency; there are no raised beaches, the result of marine denudation, no drifts left by tidal erosion, and no moraines left by glaciers.

After a visit to Pennington Lane, which affords a grand view over the Medway valley and some of the richly-wooded lateral valleys, the party proceeded towards Tunbridge Wells.

On the way, Mr. Lobley pointed out an outlier of the Weald Clay at Mrs. Newnham's brickfields. Arriving by Mount Ephraim on the famous and beautiful Common, the higher valleys of the district were seen, and the summit of the Weald, Crowborough Beacon, at length bounded the view. The Tunbridge Wells Sand is conspicuously displayed in the picturesque "rocks" which stud the higher parts of the Common near Mount Ephraim. The sand is so well compacted that soft sandstone is the result, and, where it is harder than elsewhere, greater resistance to weathering has given outstanding masses, some most grotesque in form and appearance.

Permission was kindly given to visit the charming grounds of the Spa Hydropathic Establishment, which fronts Bishop's Down at the eastern extremity of the Common. In the grounds may be seen a good specimen of the beautiful little valleys which abound in the neighbourhood, and which, with the fine timber adorning both hills and valleys, render this district so attractive.

A little further to the east the Tunbridge Wells Sand is again characteristically seen on Rusthall Common, where the rocks are still more striking than at Mount Ephraim. One of these masses has received the name of the Toad Rock, from its resemblance to that animal, and others, too, are known by distinct names. They are fine examples of rocks of various degrees of hardness, acted upon by atmospheric agencies.

Leaving Rusthall Common the Wadhurst Clay was seen, occupying the bottom of the Happy Valley, and the well-known High Rocks again showed Tunbridge Wells Sand, here thrown up by a fault. After inspecting these huge masses of soft sandstone, with their remarkable clefts, members made their way by the narrow valley along which runs one of the feeders of the Medway, the boundary between Kent and Sussex, to Tunbridge Wells Station, for the return to London.

EXCURSION TO TUNBRIDGE WELLS AND CROWBOROUGH BEACON.*

MONDAY, JULY 12TH, 1879.

(FIFTH OF THE WEALD SERIES.)

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by* W. FAWCETT, B.Sc.)

Proc. Vol. vi. *p.* 230.

On alighting at Tunbridge Wells the members proceeded to the Parade, the Pump Room, and, after crossing the boundary of Kent and Sussex, to Broadwater Down. Here, with almost the whole of Tunbridge Wells in view, Mr. Lobley pointed out that the town was built at the junction of two valleys. The higher ground is Tunbridge Wells Sand, with outlying patches on Rusthall Common and elsewhere of Weald Clay, while in the valleys Wadhurst Clay occurs.

The Marquis of Abergavenny had invited Mr. Lobley to conduct the members through Eridge Park to the Castle, and had kindly instructed Mr. Rush, of Eridge, to accompany the party, and point out everything of interest in the magnificent domain, one of the oldest enclosed parks in the kingdom. At Eridge Castle two iron cannon balls were exhibited, the first made in England. Prof. Morris referred their manufacture to the year 1543, when the first cannon of English make was produced at the then famous Sussex furnaces. A hundred years later, during the Civil War, many of the furnaces were destroyed, and from that time the gradual extinction of the old forest of the Weald, and the consequent loss of fuel, led to the decline and ultimate cessation, in the beginning of the present century, of the Wealden iron furnaces. But the loss has only been a local and a temporary one. Some three or four of the ironmasters of Sussex, finding fuel growing scarce in their own country, established themselves in Wales, and were the first promoters of the iron-trade of Merthyr Tydvil and Aberdare.

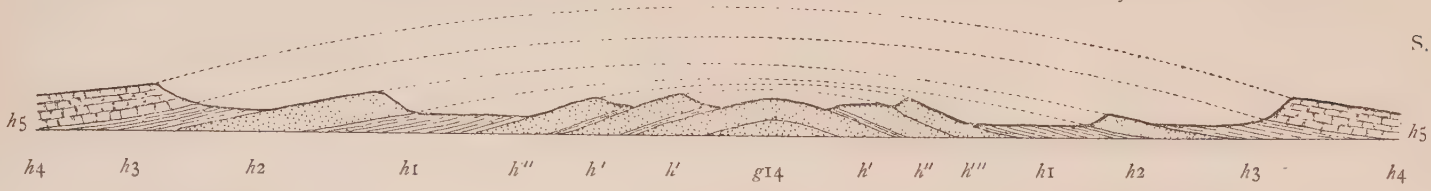
From the lawn in front of the Castle there is a good view of the well-wooded Wadhurst Clay Valley, which forms a large portion of the grand old park. The Eridge Rocks in another

* As this excursion is the last of the "Weald" series, it is here included among Kentish excursions, though itself mainly in Sussex. Tunbridge Wells is on the Kentish side of the border.

portion of the park were examined, and compared in many points with the Toad and High Rocks. The position of the Eridge Rocks, inasmuch as they are in a sheltered position, seems to militate against a theory of Sir A. Ramsay, who endeavoured to account for the peculiar undercutting by pointing out the enormous force with which the wind files away at the base of the rocks by means of the sand—a natural emery powder. A discussion arose with regard to the origin of the hemispherical markings. Mr. Lobley suggested that they were structural, and compared them with the "box-stones" of the Sevenoaks Quarries. Professor Morris pointed out that they followed the lines of false bedding. This false bedding proves the existence of varying currents in the great river which laid down the Tunbridge Wells Sand as part of its delta. Attention was called to a very "clean" cleft. It is remarkable that these "clefts" run parallel in a direction nearly N.W. and S.E.

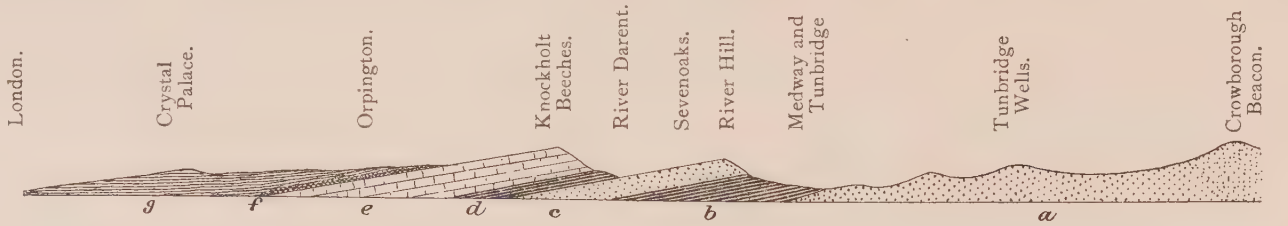
The party left Eridge and followed the road to Uckfield. Gradually ascending, they soon found themselves on ground commanding most extensive views, as well over the cultivated region as over the wild expanse of Ashdown Forest, stretching away to the west. Still ascending, Crowborough was at length reached, and standing on the summit Mr. Lobley reminded the members that they had now arrived at the anticlinal axis of the Weald, from which the beds dipped north and south; that they had traversed first the long northern slope of the Chalk ridge of the North Downs, had then descended its steep escarpment on the southern side, crossed the Gault vale, and, at Sevenoaks, the Lower Greensand ridge, and then the Weald Clay valley of the Medway, followed by the Tunbridge Wells Sand ridge and the Wadhurst Clay vale, from which they had ascended the great swelling mass of Ashdown Sands, on which they now stood. The parallel ridge and valley character of the country had been well seen; the long slopes and the escarpments, the varying character and appearance of the country, and the change of vegetation following the change of formation had been noted. Professor Morris remarked on the absence generally of gravel beds in the Wealden area, and said that where these did occur they went to prove that the direction of the rivers had always been the same, though S. V. Wood, jun., maintained that the contrary was the case in the north, from the existence of trumpet-shaped gorges in the North Downs. He showed that if the Chalk had covered the Beacon, we should have to account for the denudation of

FIG. 26.—GENERAL SECTION OF THE WEALD. (*Dotted lines indicate the Strata removed by denudation.*)



*h*5. Chalk.
*h*4. U. Greensand.
*h*3. Gault.
*h*2. L. Greensand.
*h*1 Weald Clay.
h'''. Tunbridge Wells Sand.
h''. Wadhurst Clay.
h'. Ashdown Sand.
*g*14. Purbeck Beds.

FIG. 27.—DIAGRAMMATIC SECTION FROM LONDON TO CROWBOROUGH BEACON.
Length, 40 miles. Heights and Dips much exaggerated.



a. Hastings Sands (Ashdown Sand, Wadhurst Clay, Tunbridge Wells Sands).
b. Weald Clay.
c. Lower Greensand.
d. Gault.
e. Chalk and Upper Greensand.
f. Lower London Tertiaries.
g. London Clay.

some 3,000 feet, but it was quite possible that Crowborough Beacon formed a bank in the Cretaceous sea.*

References.

Maps.—Ordnance Survey. Geological, Sheet 6. 8*s.* 6*d.*
New Ordnance Survey. Sheets 287 and 303. 1*s.*
Books.—W. Topley, The Geology of the Weald, etc. 8vo. *London* (Geol. Survey), 1875. 28*s.*
W. Whitaker, The Geology of London, etc. 8vo. *London* (Geol. Survey), 2 vols. 1889. 11*s.*

SHEPPEY.

[*Sheppey* was first visited by the Association in 1861. (Proc., vol. i. p. 166.) The next excursion there took place in 1868, while the publication of Proceedings was suspended. The third excursion, on June 7th, 1875, is reported at some length (Proc., vol. iv. p. 320.) A fourth visit was made on May 23rd, 1881, and a short account of it appears in Proc., vol. vii. p. 149. Sheppey was also the scene of another excursion in 1887, a record of which appears in the excursion, or November, number for that year. The following account is derived from the reports of the visits in 1875 and 1881.]

EXCURSION TO THE ISLE OF SHEPPEY.

June 7th, 1875.

Directors W. Carruthers, F.R.S.; Major F. Duncan, R.A., and W. H. Shrubsole, F.G.S.

(*Proc. Vol.* iv. *p.* 320.)

On arriving at Queensborough, the members were met by Major Duncan and Mr. Shrubsole. Carriages were taken in the direction of Warden Point, at the extreme eastern end of Sheppey. The lower road, through Eastchurch, was chosen, and after a pleasant drive over a country at first somewhat unattractive and bare, but afterwards pretty and well timbered, with fertile vales and swelling elevations, affording glimpses of the sea to the north, the vehicles arrived at Warden Court, where, through the kindness of Mr. C.

* Sheet 77 of the Horizontal Sections of the Geological Survey, from Newhaven to the North Downs two miles S.E. of Farningham, in Kent, crosses Crowborough Beacon and Knole Park.

Payne, Major Duncan was enabled to give his guests a hospitable welcome.

A large collection of the fossils so abundant in Sheppey, pyritized palm-fruits (*Nipadites*), stems, chelonian and fish remains, together with coprolites and crystals of selenite, exhibited by Messrs. Boughey, Hall, and Atkins, of Sheppey, invited the attention of the party before the road was taken to the cliffs. On the brink of the cliff stand the ruins of a little church, that, not very long ago, was considered to occupy a secure position, but which now, so rapid is the destruction of the land by the sea, and so near is the church to the edge of the cliff, it cannot be long before the whole structure is destroyed. [See next report.] Close to the ruins, and with a commanding view of the crumbling masses of London Clay forming the seaward face of Sheppey, the visitors assembled to listen to the President's account of the Flora of the London Clay of Sheppey. (*See* Proc., vol. iv. p. 318.)

Following Mr. Carruthers, Mr. W. H. Shrubsole, who has been resident in the island for twenty years, informed the visitors that the stems, as well as the fruits of plants, were often found. Landslips here were frequent, and were sometimes extensive, as much as five acres of land having given way at one time. There was a terrace, or lower cliff, which formed, as it were, a buttress to the upper, and, while this endured, the upper cliff remained; but when this support was destroyed by the waves, the upper cliff gave way, and so another undercliff was formed. The rapidity of the destruction of the cliffs is such, that no less than 800 tons of iron-pyrites, derived from the clay washed away by the sea, had been shipped in three months. *Septaria* are also numerous, and these calcareous masses being washed out like the pyrites, were collected on the beach, and used for the manufacture of cement.

A path along the edge of the cliff led to the course of a stream, by means of which the shore was gained, and the members were enabled to examine the rugged face of the clay, which was well searched for fossil fruits. These, however, did not present themselves in great numbers, but specimens of pyrites, frequently encrusting portions of stems, were very common. Some chelonian remains were also found.

The London Clay of Sheppey has been estimated by Prestwich to have a maximum thickness of about 480 feet, and is similar in lithological character to the formation in the London Basin generally. Its dissimilarity palæontologically is, however, very remarkable. The extraordinary number of plant remains

which it contains has been dilated upon by Carruthers, and affords ground for concluding that near here a river emptied itself into the London Clay sea. This evidence of the proximity of land is in accordance with the fact that in the Sheppey area remains of turtles * are found in abundance, while they are wanting in the London Clay of Middlesex and of Surrey.

Again following the path on the top of the cliff, the site of a Roman pottery-kiln was reached. Mr. George Dowker considered it to have been a "smoulder-kiln," in which clay vessels were placed with charcoal, and the fire sustained by a current of air passing through a channel dug in the earth. At Hensbrook a second descent to the shore was made, and the face of the cliff was then observed for a long distance to the west. Mr. Carruthers described and explained the plants met with, one of which, the *Orchis mascula*, was in full flower, growing luxuriantly in a sheltered spot, and so afforded an illustration of the peculiarity of its reproductive organs.

Sheppey is mainly, though not altogether, composed of London Clay, for, in a few places, as at Minster, East Church, and at East End, a capping of sands has been observed, and these sands have been mapped by the Survey as the Lower Bagshot Sands, which, in other localities, overlie the London Clay. Perhaps the best exposure of these arenaceous beds in the island is the cliff-section near the end of East-End Lane, where they are seen overlying the London Clay, and have a thickness of about twenty-five feet.

EXCURSION TO SHEPPEY.—Monday, May 23rd, 1881.

Director—W. H. Shrubsole, F.G.S.

(*Proc. Vol.* vii. *p.* 149.)

The members were met at Sheerness station by the Director. After a pleasant drive of about nine miles, *via* Minster and Eastchurch, the cliff edge at Warden Point was reached. Six years before, when the Association visited this spot [see preceding report], the church was standing in dangerous proximity to the cliff. Since then it has been pulled down, and the materials have been removed to prevent them descending to the shore. The Director, in the course of a short address, spoke of the extensive waste of land that had occurred during the thirty years he had known the locality. He also called attention to the

* Woodward and Sherborn, Catal. Brit. Foss. Vert., 1890.

fact that whilst the fruits of endogens were very abundant, the fossil wood that came from the clay was exogenous. The absence of the endogenous wood might be accounted for by its incoherent fibrous structure, which probably caused it to float until decomposition took place. Getting down to the foot of the cliff, fossils were eagerly looked for amongst the shingle, pyrites, and fragments of septaria scattered on the beach and foreshore. Wood bored by *Teredo* was observed to be in abundance, and shark's teeth, crabs, and fruits were found. The best specimen was a fairly good chelonian. After a rough and slippery walk of five miles, the cliff-top was regained near East End Lane, where a good section of the Lower Bagshot Sand was examined; the junction with the London Clay below was found to be quite sharp and well-defined. Here, also, the changes that had taken place between the two visits of the Association pointed to the conclusion that the land-area of Sheppey had, even in these six years, been considerably lessened.

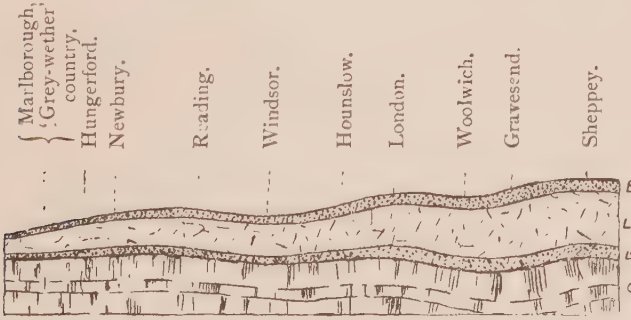


FIG. 28.—IDEAL SECTION OF LONDON CLAY (PRESTWICH).

B. Bagshot Series. Lr Ts. Lower Tertiaries.
L.C. London Clay. CH. Chalk.

REFERENCES.

MAPS.—Ordnance Survey. Geological. Sheets 2 (4*s.*) and 3 (8*s.* 6*d.*).

New Ordnance Survey. Sheets 272, 273. 1*s.* each.

BOOKS.—W. Whitaker, "The Geology of the London Basin," 8vo. *London* (Geol. Survey), 1872. [For literature.] 13*s.*

H. B. Woodward, "Geology of England and Wales," ed. 2. 8vo. *London*, 1887.

J. S. Gardner, "Notes on the London Clay and its Deposition," *Proc. Geol. Assoc.*, vol. x. (1887), pp. 115-122.

THE NEIGHBOURHOOD OF ROCHESTER.

[Of the details of the first visit of the Association to *Rochester* in 1866 no record exists. In 1880 an excursion to *Upnor* was made, details of which are given below.]

EXCURSION TO UPNOR.—Saturday, May 8th, 1880.

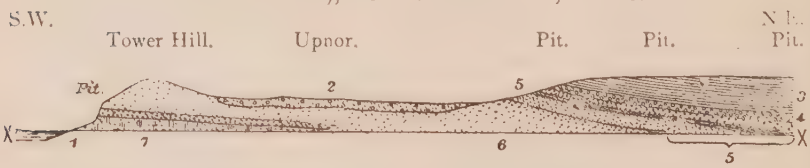
Director—W. Whitaker, F.R.S.

(*Report by*—The Director.)

(*Proc. Vol.* vi. *p.* 336).

On leaving the railway at Strood, the party took the footpath up Frindsbury Hill, where a halt was made and the features of the district were explained, including the dip-slope of the Lower Greensand (seen through the gap in the Chalk ridge made by the Medway) and the tendency of the Chalk to have a small second escarpment, of which the standpoint was an example.

Fig. .—Diagram Section along the Left Bank of the Medway, near Upnor, 1⅓ Miles (Vertical Scale exaggerated), by W. Whitaker, F.R.S.



X Sea Level.
1. Alluvium.
2. Gravel.
3. London Clay
4. Oldhaven Beds; Sand with Pebbles and Shells.
5. Woolwich Beds; Sands with Clay Shell-bed in the middle and Pebbles at the bottom.
6. Thanet Beds: Sand, the bottom part clayey and greenish.
7. Chalk with Flints.

Lower London Tertiaries.

The large chalk-quarries by the river side, on the south-east, were then visited. Here some well-marked layers of flint were noted, and also some pipey masses of irregular gravel on the Chalk, apparently the remains of a high terrace of Medway Gravel.

The walk having been continued northward, the party came to the most southerly of the Upnor sections, a disused pit at the south of Tower Hill, showing the junction of the Thanet Sand and the Chalk with the usual greenish bed and its green-coated flints.

Proceeding by the side of the Medway until, just before

reaching the village of Upnor, a new section was seen in the River Drift, which here cuts across the low hill. It showed some feet of brick-earth, with gravelly layers, over gravel. Attention was then drawn to the spot, on the opposite side of the river, where *the largest fossil in the world* (a Dutch war-ship) had been found in the alluvium during the works of the new Chatham Extension Dockyard.

The party straggled somewhat through the village, presumably to investigate the water-supply, but was soon re-united in the first of the great Tertiary sections. In this pit the junction of the sand of the Woolwich Beds with the Thanet Sand was seen; but the Clay Shell-beds of the former and the overlying Oldhaven Beds and London Clay could only be got at with difficulty. From the north-east dip, however, these higher beds are brought down in the next pit, at the back of the cement-works.

Here the frequent occurrence of selenite was noticed, not only in the London Clay, but also in the underlying beds. In the London Clay here it often occurs in thin sheets along joint-fissures, as well as in detached crystals or masses of crystals. In the estuarine shelly clays of the Woolwich Beds masses of crystals also occur, whilst in the intermediate Oldhaven Sand a peculiar variety is found, consisting of masses in which the fine grains of sand have been caught up between the plates of the crystals, forming, indeed, a sort of sandstone, which sometimes makes casts of the shells, and sometimes occurs in layers some feet long. This variety of the mineral has been found only in two chief Kentish sections of the Oldhaven Sand, those of the Upnor pits, and of Reculver cliffs. A number of fossils were obtained from the Oldhaven Beds; but the estuarine shells in the midst of the Woolwich Beds were mostly hidden by talus.

In the furthest pit the London Clay, with its septaria, was well seen, whilst the shelly clays of the Woolwich Beds could be worked at the floor.

A return was then made to Rochester, and the visit was brought to an end by a stroll to the Norman keep of Rochester Castle, from the top of which a fine view was obtained.

[For details of the sections seen the reader is referred to Whitaker, Geology of the London Basin, *Geol. Survey* (1872), pp. 28, 73, 143-145, 360.]

References.

Maps.—Ordnance Survey. Geological. Sheets 1, S.E. 3*s.*; 6, 8*s.* 6*d.* New Ordnance Survey. Sheet 272. 1*s.*

EXCURSION TO HIGHAM, KENT.—June 18th, 1881.

Director—W. Whitaker, F.R.S.

(*Report by* The Director).

(*Proc. Vol.* vii. *p.* 189.)

The object of this excursion was to examine some cuttings on the railway through the hundred of Hoo, which have laid open good sections of the Lower Tertiary beds.

The members assembled at Higham Station, the Rev. C. H. Fielding, of Higham, kindly placing his knowledge of the country at their service. Progress was also much aided by Mr. H. Russel, of Cliffe, by whose good offices the party was carried along the line by a contractor's engine and truck.

It may be better to describe the cuttings from west to east, without regard to the order in which they were actually seen, merely remarking that the district is part of the slight trough between the Thames and the Medway, and is bounded on the south by a wooded range of London Clay hills, and on the north by the marshes of the Thames, interrupted by the rise of the Chalk at Cliffe.

The new railway leaves the North Kent line some three miles E. of Gravesend, passes at first over a small flat of river-gravel, and then crosses the Canal, where a good deal of peat, with remains of trees, has been found, to an island in the marsh, west of Higham. Here there is a small cutting in brown London Clay. The line then runs over the marshes for more than a mile, until near Cliffe Rectory, just to the south of which is a long and deep cutting excavated in Thanet Sand, and very wet at the bottom. In the middle of this sand are seen here and there signs of slight erosion, or of gentle current bedding, a most unusual thing in this division of the Lower London Tertiaries. The next cutting eastward is small, and seems to be in the same sand; but the party did not stop to examine it.

The chief cutting is through the hill eastward of Cooling Court, and it shows the whole of the beds from the bottom of the London Clay to the top of the Thanet Sand. Owing to the westerly slope of the line, and to the slight easterly dip, the lowest beds are cut into only towards the west, whilst at the east the shelly clay of the Woolwich Beds sinks to the level of the rails. The Beds are

as follows and they occur in even succession without any erosions :—

Brown clay, apparently LONDON CLAY, but without any sign of the usual pebbly basement-bed ; up to about eight feet.

OLDHAVEN BEDS.
- Fine buff slightly false-bedded sand, with masses of fossils in places (*Cardium*, *Pectunculus*, *Natica*, *Corbula*, *Lamna* teeth and vertebræ, and pieces of carapaces of Turtle) ; up to eight or ten feet.
- Small flint-pebbles in sand, generally about six inches ; but in one part nearly three feet.

WOOLWICH BEDS.
- Light-coloured sand, with incipient tubular concretions (?), about seven feet.
- Shelly clay (*Cyrena*), about three feet.
- Sharp grey sand, with traces of peaty matter in the upper part ; many feet but the whole thickness not seen at one place.
- Thin layer of very small flint pebbles in pale greenish sand.

Fine soft THANET SAND ; a few feet.

At the eastern end of the cutting there is a mass of brown brick-earth, probably the result of the wash of the hill. Many fossils were collected from the Oldhaven Sand ; but it is to be feared that few were successfully carried home, on account of their perishable nature.

A small unfinished cutting, a little further east, is in sand, which probably forms part of the bed beneath the shelly clay.

After tea the party strolled into the combined cutting and pit at Higham Station, and noticed the junction of the Thanet Beds and the Chalk, thus continuing and completing the downward procession of the Tertiary Series. A persistent layer of flint through the midst of the Chalk was also observed.

[An excursion to Higham, F. C. J. Spurrell being Director, took place on June 22nd, 1889. (See Proc. vol. xi. p. 72.)]

REFERENCES.

MAPS.—Ordnance Survey. Geological. Sheet 1 S.E. 3*s*.
New Ordnance Survey. Sheet 272. 1*s*.

BOOKS.—W. Whitaker, "The Geology of the London Basin," 8vo, *London* (*Geol. Survey*), 1872. 13*s*.

F. C. J. Spurrell, "Embankments of the Estuary of the Thames," *Archæol. Journal*, vol. xlii., 1885, p. 269.

EXCURSION TO THE GORGE OF THE MEDWAY, AND KIT'S COTY HOUSE.—Monday, May 1st, 1870.

Director—Professor J. Morris, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 503.)

The party from London entered the valley of the Medway at Strood, opposite Rochester. From this point the Maidstone branch of the railway is carried up the remarkable gorge in the Chalk, through which the waters of a large portion of the Weald find their way into the sea. This is one of the four great breaks which traverse the North Downs. At Snodland, which is situated upon the Gault, the funnel-shaped entrance to this gorge, on the escarpment side, is very apparent.

Here the party descended from the train and crossed the Medway towards Burham, where there are extensive quarries in the Lower Chalk. These yielded several interesting fossils, and amongst others true coprolites, often mistaken for conical fruits. Some of the members thence ascended towards the Middle Chalk of Blue-bell Hill, where, under the guidance of Mr. Johnson, they found several ventriculites. The bulk of the party followed Professor Morris along the road at the base of the escarpment. This road crosses a country much covered by grey wethers. Four immense stones of this kind, relics of the Lower Tertiaries, constitute the remarkable monument known as Kit's Coty House, said to be the finest cromlech in the south-east of England. It is situated towards the middle of the Chalk escarpment, and commands a complete view up the valley of the Medway in the direction of Maidstone. Here the Director took the opportunity of delivering an instructive address upon the subject of the denudation of the Weald, and the formation of these remarkable gorges, at the entrance of one of which the party was then standing.

Looking at the controversy which had long been waged between the rival champions of marine and sub-aerial denudation, he considered that it must be admitted that the latter had, in a great measure, proved their case, and that in point of fact a considerable portion of the clays of the longitudinal valleys of the Weald had been removed in the course of ages and carried down through these gorges, which were themselves the result of erosion of the harder beds, acting in all probability upon lines of weak resistance, and partly also determined by an alteration in

the strike. Therefore the scooping out of the great longitudinal valleys, as well as the erosion of the transverse valleys, must be in a great part due to rain and rivers, which have been acting ever since the rise of the old Wealden dome. The Quaternary beds of the Medway Valley are of the highest interest, and extremely fossiliferous, but are most extensively developed and contain the greatest quantity of remains in the funnel-shaped mouths of the gorges such as this at Aylesford, and also in the same valley above Maidstone, where there is an analogous break in the Lower Greensand escarpment. At such places there seems to have been a great spreading out of the waters, arising from a choke in the narrows during times of flood. This gave rise to temporary lakes, into which the carcases of animals were floated. At present Aylesford is only about thirty-eight feet above the sea-level, and yet there seems to be evidence that the Medway flowed at a far higher level during a period when the neighbouring fauna was much the same as when the elephant-gravels of the Aylesford pits were formed. For in the heights above Maidstone, gravels occur at elevations of 300 feet, containing nearly the same kind of bones as those of the lower terraces. The inference is that the Medway has done much excavating work during the period which elapsed between the deposition of these high-level gravels near Maidstone and the low-lying gravels of Aylesford.

The party then adjourned to the gravel-pit, where a most striking section was exposed. At the base, twenty feet of almost pure white sand, the bleached and incoherent Folkestone Beds of the Lower Greensand were seen. On this reposed a splendid series of mammaliferous gravel and sand, bearing evidence of much erosion, hollowing out, and redeposition by current action ; indications of ice-action were also noticeable. Though three-fourths of the recognisable pebbles and stones consisted of Chalk flints, there were noted boulders of the Folkestone Beds, huge masses of Kentish Rag, and other fragments of Lower Greensand, with *Gryphæa sinuata*, and a few well-rounded fragments of Wealden (Hastings) rock with *Cyclas*. The presence of these last was held to indicate that the direction of the pebble-transporting currents must have been from south to north, or in the same direction as that in which the river now flows, and may be deemed to supply evidence against those who consider the bell-mouthed entrance of the Medway gorge a proof of the old river having discharged itself in a southerly direction. Many teeth of *Elephas*, together with other fossils, were secured by members, and the whole

party had the satisfaction of seeing an immense curved tusk, not less than 10 feet in length, which formed a prominent feature in the face of the section. Two fine teeth of *Rhinoceros* were also found.*

The next place visited was the brickyard, where about 50 feet of Gault and Chalk Marl were visible. At the time of the visit the base of the working was about on a level with the *Ammonites varicosus* zone of Folkestone, and the following were some of the fossils noted :—*Belemnites minimus*, *Nautilus* sp., *Hamites* sp., *Ammonites varicosus*, *A. lautus* (var.), *A. inflatus*, *A. splendens* (perhaps derived), *Alaria Orbignyana*, *Dentalium decussatum*, *Inoceramus sulcatus*, *I. concentricus*, *Nucula pectinata*, *Pentacrinus Fittoni*, *Trochosmilia sulcata*. The upper portion is less fossiliferous, and is succeeded by Chalk Marl with very little intervening Upper Greensand.†

This Chalk Marl, which forms the top of the excavation, was observed to be sliding forwards down the face of the quarry in a sort of viscous condition, and with its surface crevassed exactly like that of a glacier.

References.

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New Ordnance Survey. Sheets 272, 288. 1*s.* each.

Books.—W. Topley, Geology of the Weald, 8vo, *London* (*Geol. Survey*), 1875. 28*s.*

C. Bird, The Geography and Geology of the Rochester District, *Rochester Naturalist*, No. 1, 1883, pp. 4-10.

C. Bird, Old Medway Muds and their Teachings, *ibid.*, Jan., 1884, pp. 46-48.

A. W. Hood, Chalk of the Medway Valley, *ibid.*, April, 1884, pp. 57-63.

* A depth of nearly 20 feet of gravel was here seen resting on the sands of the Folkestone Beds. It was false-bedded with sand, fine gravel, and loam. Many bones have been found here, chiefly *Rhinoceros* and *Elephas primigenius*. Boyd Dawkins identifies one of the specimens from this place as *Elephas antiquus*, Falc. This fossil has been recorded from no other locality within the Weald. The terrace to which the Aylesford Gravel belongs spreads in a continuous sheet from the Burham Gault Pits to near Cob Tree.—W. Topley, Geology of the Weald, 1875, p. 174.

† The pits at Aylesford and Burham give some of the best sections of the Gault in the interior; usual thickness, 100-120 feet, as at Snodland. About 18 inches of "greenish-grey marly sand," with dark grains, phosphatic nodules, and cream-coloured concretions, are interposed between the top of the Gault and the Chalk Marl.—W. Topley, Geology of the Weald, pp. 47, 153.

[An "*Excursion to the Medway Valley from Maidstone to Aylesford*" took place on July 14th, 1883, J. Logan Lobley being Director. An account of the route taken, and sections visited, may be seen in Proc., vol. viii. pp. 192-4. Mr. Lobley refrained from giving full details on account of the existence of three other reports of excursions to this locality.]

MAIDSTONE.

[*Maidstone* was one of the three places visited by the Association during 1860 (June 19th), the first year during which any excursions took place. There is a brief report of it in Proc., vol i., pp. 63-4. The party was under the guidance of the Rev. T. Wiltshire, who was then President, Prof. Tennant, and Mr. Bensted. The Iguanodon Quarry and the Charles Museum were first inspected, and the party thence proceeded to Kits Coty House and *Aylesford*, visiting the pit in River Drift, which is fully described in the report of the *Excursion to the Gorge of the Medway*, on a previous page. The next excursion to *Maidstone* was on April 2nd, 1872, from the report of which the following details are extracted.]

EXCURSION TO MAIDSTONE.—April 2nd, 1872.

Directors—Professor T. Rupert Jones, F.R.S.; Professor Tennant, F.G.S.; and W. H. Bensted.

(*Proc. Vol.* iii. *p.* 38.)

On arriving at Maidstone, the party was met by Mr. W. Bensted, jun., and conducted to the "Charles Museum," the free public museum of the town, in a fine old manor house. Many of the rooms are filled with a miscellaneous collection of antiquities, pictures, and other objects of general interest, amongst which may be specially mentioned a valuable collection of Saxon weapons, utensils, and ornaments, found at Sarre, near Canterbury. In the old picture-gallery is a collection of fossils, and conspicuous among these are some beautiful Chalk fish-remains, from Barham Downs, near Maidstone. These are chiefly of the genus *Beryx*, with one or two specimens of *Dercetis elongatus*. In a small upper room is a collection which gives a special value to the Maidstone museum, consisting of the vegetable remains found in the Lower Greensand of the neighbourhood of Maidstone, collected during many years by Mr. Bensted.

The following species, amongst others, are here represented :— *Endogenites erosa*, the leaves of a cycadean plant (*Clathraria*), *Dracæna Benstedi*, and the fragment of a dicotyledon bored by a mollusc, and misnamed *Stigmaria*.

After luncheon the party proceeded to the well-known Iguanodon Quarry, from which Mr. Bensted obtained the specimen described by Mantell, and now in the British Museum. The quarry in which this valuable fossil was found is not now worked, and the sections are obscured by *débris*. There is, however, in the quarry a ridge which may easily be mistaken for a mound of rubbish deposited by the quarrymen, but which is of far more ancient origin, since it is no other than the Post Pliocene infilling of a great fissure in the Lower Greensand. The rock having been removed on either side by the operations of the quarrymen, the mass filling the fissure has been left as a dyke-like ridge. It consists of argillaceous matter, and "gravel composed of angular broken Chalk flints, flint pebbles, subangular fragments of the Hastings Sandstone, and a few pieces of ironstone from the same beds, with angular chert, and, rarely, quartz pebbles." (Bensted, Proc. Geol. Assoc. vol. 1, No. 5, p. 58).

In the fragments of ragstone lying about the quarry were found numerous specimens of *Molluskite*. This name was given by Dr. Mantell to certain small, dark-coloured masses, believed by that author to owe their origin to the animal matter of molluscs.

At a short distance from this interesting quarry, a point is gained from which an extensive view is obtained, embracing a considerable portion of the valley of the Medway, and the geological structure of this part of Kent is distinctly seen.

An extensive quarry belonging to Mr. Bensted was next visited, and the Kentish Rag well seen. This valuable building stone is a tough, bluish limestone, occurring in layers of from a foot to three feet in thickness, and alternating with beds of a soft, sandy stone called hassock. Some of the best of the ragstone contains 90 per cent. of carbonate of lime, while the hassock has but ten or twelve per cent. The amount of ragstone quarried in the neighbourhood of Maidstone is very great, Mr. Bensted alone sending away nearly 1,000 tons weekly. This rapid removal of the rock has been going on for centuries ; most of the ancient churches and castles of Kent being constructed of this material, and so ancient a building as the White Tower of London is partly built of Kentish rag. Two blocks of the ragstone, lying at the

bottom of the quarry, on being split, showed faces covered, in the one case with *Trigonia alæformis*, and in the other with this species and *Gervillia anceps*.

Associated with the rag is a considerable quantity of chert, containing spiculæ of sponges. Fossil wood is often found in these beds, and some of this is bored. Leaving the ragstone quarries, a path following the course of the river was taken. At a little distance in this direction there is a tramway to the river bank through an old quarry, in which are seen as many as twelve of the dyke-like ridges, one of which was observed in the Iguanodon Quarry. These, the infillings of fissures in the Lower Greensand, are parallel to each other and to the river valley. The argillaceous earth of which they are largely composed is a good brick-making material.

After passing the interesting and picturesque ruin of Allington Castle, the river was crossed at Allington Lock, and the village of Aylesford was soon reached. Near this village a very fine section is exposed. (See *Excursion to the Gorge of the Medway*, p. 52.)

[The third excursion to *Maidstone* was on July 10th, 1880, Professor J. Morris being Director. The party visited the Charles Museum, the Iguanodon Quarry, the Preston Hill Quarries, and the *Aylesford* Post Pliocene deposits. (See Proc., vol. vii. p. 392). Another excursion was made July 10th, 1886. Of this a full report by the Director, Professor Boulger, may be seen in Proc., vol. ix., No. 8,] p. 551-4]

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HERNE BAY AND RECULVER.

[*Herne Bay and Reculver* were first visited on June 26th, 1863. The following details of this excursion are taken from the report by *George Dowker*, the Director.]

(*Proc., Vol.* i., *pp.* 339-345.)

On arrival at Herne Bay the party, about thirty in number, proceeded in conveyances to Reculver, passing on their way various sections shown near the bridge-crossings of the Herne Bay and Margate (L. C. & D.) Railway, then being constructed. On alighting at Reculver they first went to see the church and Roman camp. Descending from the churchyard they found the cliff composed entirely of Thanet Sand. At its base were tabular, concretionary blocks of indurated sandstone; these blocks generally rested upon a very fossiliferous deposit, shells of the genus *Cyprina* being often in great abundance. Passing along the shore towards Herne Bay, the Thanet Sand was seen to dip in a westerly direction till it disappeared at Bishopstone, the Woolwich Beds forming the lowest beds. Above the Woolwich Beds were the light-coloured sands with concretionary masses of red sand, containing much iron, and thin pebble beds towards their base, termed by Prestwich the basement bed of the London Clay.* But before reaching Bishopstone the London Clay proper had appeared above this light-coloured basement bed, and, the dip continuing westerly, towards Herne Bay the London Clay formed the entire cliff.

The Thanet Sands contain many fossils, but few species, *Cyprina Morrisi* being the most common. In the Woolwich Beds the most abundant genera are *Corbula*, *Dentalium*, *Cucullæa*, and *Cyprina*.

EXCURSION TO HERNE BAY.—6TH JUNE, 1870.

Director—Prof. J. MORRIS, F.G.S.

(*Proc. Vol.* ii. *p.* 38.)

ON arriving at Herne Bay the party proceeded eastward along the shore, and examined the Lower Eocene strata, which are so well exposed in the fine coast section between Herne Bay and the Reculvers.

These strata consist, in ascending order, of the following groups:—

1st,—Thanet Sands.

2nd,—The lowermost beds of the Woolwich Series.

3rd,—The Oldhaven Beds.

4th,—The lower beds of the London Clay.

Of these the Oldhaven Beds are perhaps the most interesting,

*The Oldhaven Beds of Whitaker, and now generally recognised by that name.

since here is seen the section at Oldhaven Gap, from which the beds are named, little more than a mile east of the Reculvers.

The "Oldhaven Beds" were so named by Whitaker; and in his paper "On the Lower London Tertiaries," in the Quarterly Journal of the Geological Society, vol. xxii. p. 404, is a list of organic remains obtained from them. (Repeated in Proc. Geol. Assoc., vol. ii. p. 39). A still fuller list may be seen in his Memoir on "The Geology of the London Basin," 1872, p. 579.

From Grove Ferry these beds continue along the Valley of the Stour westward for a considerable distance. But about five miles west of Canterbury their outcrop takes a northerly direction, and extends to the marshes south of Whitstable Bay. Outliers are also found to the west of the mouth of the Swale; and in the Western Division of Kent a sandy pebble-bed, seen at Blackheath, Abbey Wood, Shottenden Hill, and Sundridge, is considered the equivalent of the Oldhaven Beds. At Oldhaven Gap, however, the beds consist chiefly of a fine light-buff sand, from 15 to 20 feet thick, under which lies a sandy pebble-bed, about two feet in thickness.

[At Easter, 1875, at the conclusion of an excursion to the *Isle of Thanet*, the party left *Margate* by the midday train for *Herne Bay* on the Tuesday, in order to inspect the coast sections between *Herne Bay* and *Reculver* before returning to London. The following details are taken from the Report of the *Thanet* excursion (Proc., vol. iv. p. 260; see p. 61)].

From Herne Bay the party proceeded in carriages to Oldhaven Gap.

Here Mr. Dowker, the Director, pointed out the beds in ascending order, from the base of the cliff looking towards Herne Bay; first the Woolwich Beds, resting at or near a junction with the Thanet Sands (for the division was very obscure); these were here capped with a thin band of pebbles which marked the junction of the Oldhaven Beds of Whitaker, and the top of this series was shown by the coming on of the London Clay, here very unfossiliferous. Proceeding towards Herne Bay a short distance the excursionists followed the Oldhaven Beds descending to the beach, where their presence was marked by the layer of lenticular sandstone stretching out into the sea. Retracing their steps, they proceeded beneath the cliff towards Reculver, Mr. Dowker pointing out the Thanet Sands and the Woolwich Beds, and the excursionists making hasty attacks on the tempting fossils exposed in great profusion beneath their feet.

Towards Reculver the tabular masses of sandstone are most abundant at the base of the cliff, and form a floor to the beach; they constitute the horizon in the Thanet Beds seen towards the top of the cliff at Pegwell Bay; this and the Reculver section representing the entire series of the Thanet Beds. A short walk brought the party to Reculver Church, where the position of the Roman Castrum, the Regulbium of the Romans, was pointed out, and a few remarks on the antiquity of the original church, its probable Saxon if not Roman origin, its connection with Richborough and its historical interest, were dwelt upon by the Director. Reculver is given by Sir Charles Lyell as an instance of the ravages of the sea; but Mr. Dowker pointed out that the parish authorities need not have been in such a hurry to dismantle their beautiful church, for the sea had certainly not gained on the shore lately, and a deposit of sand appeared to show that it did not attack so fiercely the present shore.

[*Herne Bay* was again visited on April 6th, 1885, W. Whitaker and G. Dowker being the Directors. A full report of this excursion will be found in the Proc., vol. ix. pp. 168-177. On that occasion *Canterbury* was the headquarters of the Association, Easter Monday being devoted to *Herne Bay* and *Reculver*, and Easter Tuesday to *Pegwell Bay* and *Richborough*. Those members who arrived at *Canterbury* on the previous Saturday were met by Mr. Whitaker at *Selling* Station, and were thence led southward along the flank of the wooded Tertiary escarpment to the high road (Watling Street) seeing Woolwich Sands and Oldhaven Beds on their way, and walking along the Watling Street to Canterbury.]

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THE ISLE OF THANET.

[Besides the excursion to *Pegwell Bay* and *Richborough* on Easter Tuesday, 1885, the *Isle of Thanet* was visited by the Association on Easter Monday and Tuesday (March 29th and 30th), 1875. Below is the report of this excursion. No record exists of a visit to the Isle of Thanet which took place on August 4th, 1866.]

EXCURSION TO THE ISLE OF THANET.

Easter Monday, March 29th, 1875, and following day.

Director—George Dowker, F.G.S.

(Report by W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 254.)

The party quitted the railway station, at Ramsgate, shortly after one p.m. on Easter Monday, and proceeded at once towards Pegwell Bay. Arrived on the shore, Mr. Dowker began by pointing out, in the first place, an irregular mass of gravel and brick-earth, generally believed to be of fluviatile origin. It rested, in this place, directly upon the Chalk, and was considered to be of the same age as certain high level gravels resting on the Lower Tertiaries near Herne Bay, in which palæolithic implements had been found. Some geologists had referred its deposition to the Mid-Glacial period, but there seemed to be much doubt as to this. *Buccinum* and *Ostrea* had recently been found in the deposit, but whether these got in from above or were really a part of the deposit there was no evidence to show.

The Isle of Thanet is a somewhat oval mass, of moderately high ground, separated from the mainland of Kent by a belt of marsh, which, though now banked in and drained, has within the historical period been a shallow strait into which the estuary of the river Stour discharged, and which communicated freely with the sea, on the north, at Reculver (Regulbium), and on the south-east near Richborough (Rutupiæ) The chief rock of the isle is Chalk, which rises in a sort of gentle anticlinal swelling, having an axis with a mean direction, E.N.E.—W.S.W. It falls away also to the westward, whilst on the east its section by the sea prevents us from forming an idea as to how far the axis might be prolonged in this direction. This Chalk of Pegwell Bay is the same as that of Margate, and is the highest in the county, perhaps

as high as any in England, the general *facies* of its *fauna* having much resemblance to that of Norwich. It is remarkable for the small amount of flint contained, and this circumstance induced geologists formerly to suppose that this Thanet Chalk was really Lower Chalk. It also contains Ammonites; indeed there seems to be some connection between flintless Chalk and Ammonites which may be more than accidental. It is to be noted that the Ammonites occur in casts. From the appearance of large Ammonites, Prestwich was led to conclude that the Kentish Chalk represented the Medial Chalk of England, but their appearance at Dover and Margate in widely separate beds will not warrant this conclusion. The few flints there are appear, for the most part, to be fossil sponges.

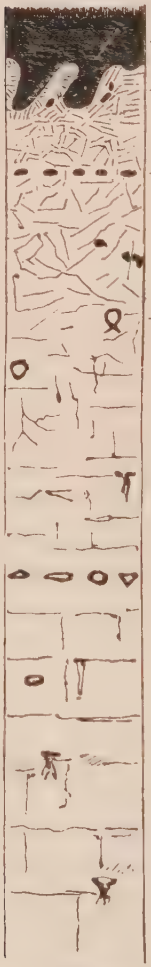

FIG. 39.—GENERAL VERTICAL SECTION OF THE MARGATE CHALK.

There is a slight fault in the cliff at Pegwell Bay, which brings up the Chalk against the Thanet Beds; considerable irregularity in the dip is noticeable, with a balance towards the S.W. There is, generally, however, a very marked southerly dip of the Chalk on this side of the Isle of Thanet, in the direction of the Stour Marshes, which lie in a well marked synclinal filled with Tertiary beds. Pegwell Bay itself may be viewed as a seaward continuation of this synclinal hollow. The junction of the Chalk and Thanet Sands may be seen in the low cliffs of Pegwell Bay. The well-known green-coated flints, so constant an attendant upon this junction, not only with the Thanet Sands, but with other

permeable beds of the Lower Tertiaries, came in for a large share of attention. "It is a peculiar feature of these junction sections of Chalk and Thanet Sands, as seen in East Kent, that the green-coated flints nearly always rest on a semi-tabular mass of Chalk flint." (Dowker, *Geol. Mag.*, 1866, p. 210.) This peculiarity was well observed on this occasion by the party in Pegwell Bay. The green coating is said to be due to a deposit of hydrous silicate of iron as a sort of glaze.

The lower beds of Thanet Sand, at Cliff End, are very fossiliferous. *Dentalium nitens*, *Natica subdepressa*, *Cyprina Morrisi*, *Cytherea orbicularis*, *Nucula Bowerbanki*, *Ostrea bellovacina*, *Panopea granulata*, *Pholadomya cuneata*, *Pholadomya Koninckı*, *Thracia oblata*, are the most abundant and characteristic species.

There is one bed seen in the low cliffs about four inches thick, which is a mass of shells, chiefly *Cyprina Morrisi*. This species, with many others, also occurs throughout, the shells being sometimes very fine, and in good preservation.

At the "Sportsman," (Red Cliff End Point) the whole party proceeded in conveyances by a road made along a remarkable pebble beach which extends from the Isle of Thanet almost to Sandwich. At a break in this pebble beach, called Ebsfleet, the Ordnance Map has the following legend, "Here the Saxons first landed."

The party dismounted at the Salterns, and crossed the Stour, a sluggish river some thirty yards wide, in which a feeble neap tide was slowly rising. A walk of less than a mile across the marshes, but still close to the river, brought them to the foot of the singular island on which the Roman castrum of Richborough (Rutupiæ) was constructed. This is an island of Thanet Beds, capped by Woolwich Beds. About the junction is a persistent line of *Corbula* and other shells in a silicified condition. The railway to Deal shaves off a portion of this hill, and whilst the line was being made specimens were easily obtained; not so at present.

Mr. Dowker remarked on the singular fact that, although the Norwich Chalk contained fossils very similar to that of Thanet, we have here, immediately reposing on the Chalk, the lowest of the Tertiaries known in England; whereas, in Norfolk, we have for the most part the highest and newest Tertiaries in a similar position. He again also took the opportunity of showing that the existence of *Ammonites*, made known to the members by the Paper of Mr. Bedwell, was no longer to be deemed a proof that

the Thanet Chalk occupied a lower zone. Speaking of the Tertiaries he observed that nowhere else in England could such low beds of Thanet Sands be seen, and these contained very numerous marine remains. The Woolwich Beds, of which a cap existed here (pointing to the platform forming the summit of the island), were also marine, and less characteristically developed than in the neighbourhood of London, where, as was well known, they were markedly estuarine in character. The President (Mr. W. Carruthers) had formerly determined for the speaker a very interesting specimen of *Pinites*, found about the junction between the Thanet and Woolwich Beds. Alluding now to the remarkable deposits of gravel which occur in East Kent at considerable elevations, both upon the Chalk and upon the Tertiaries, and which contain worked flints, Mr. Dowker stated his belief that these were of high antiquity. Dr. J. Geikie considers them to occupy an Inter-Glacial period, and one anterior to the date in which the Boulder Clay was deposited; they occur in the south-eastern portions of England, and he considers their absence further north and west is to be accounted for by their having there been obliterated by the Glacial sea which deposited the Boulder Clay, which latter is not found in the east of England south of the Thames. The palæolithic gravels of East Kent must have been, according to Dr. Geikie, elevated above the reach of this Glacial sea. Kent would thus present to us a very old land surface. From many considerations it is evident that since the deposition of these gravels the Thames must have deepened its bed by 100 feet.

The party then proceeded to Richborough Castle. A low rectangular wall, about fifteen feet in thickness, composed chiefly of flints, encloses a flat quadrangle about five acres in extent, now wholly given up to the plough. A sort of pit towards the middle of the enclosure conducts to an underground passage. The view from this isolated table must, on a clear day, be very instructive physiographically, as it commands the synclinal hollow of the Stour marshes, with the great curve of Thanet on the north, and the still bolder swell of the long range of Chalk heights, forming the backbone of East Kent, on the south.

On the following morning the low cliffs of the Margate Chalk occupied the attention of the party. Much interest in these beds had been excited by the publication of Mr. Bedwell's paper on "Ammonite Zones in the Isle of Thanet" (Proc. Geol. Assoc., vol. iii. p. 217). It may be as well to note a few peculiarities in

this Margate Chalk. For the general vertical section, see J. W. Wetherell "On Some Fossils from the Margate Chalk" (Proc. Geol. Assoc., vol. iii. p. 192—reproduced here, p. 62); and, generally, G. Dowker "On the Chalk of Thanet, &c." (Geol. Mag., 1870, p. 466).

It would appear that the Margate Chalk has a thickness of about thirty feet; its lower limit may be taken at the line of the three-inch flint band which terminates the great thickness of flinty Chalk. It is soft, and makes good whitening. In purity it is perhaps not equal to the Chalk with flints, as the silica is most probably disseminated instead of being collected in masses. Of mechanical sediment there is not very much. The fossils are to a great extent indicated, rather than actually preserved, by ferruginous stains, and to judge from the frequency of these markings, these are plentiful. *Ventriculite* structure is not uncommon; some nice pieces were picked up here and at Pegwell Bay, also *Brachiolites*, *Coscinopora*, and fragments of *Bryozoa*. *Belemnitella* is not unfrequent. The Ammonite Zone was found as indicated by Mr. Bedwell, and as far as may be judged from a very limited walk, the Ammonites lie in one stratigraphical horizon, though, as there is a slight curvature in the beds, the height of this line varies. Thus, the first Ammonite discovered could only be assailed by missiles from below. The next one found was at a more convenient level. These Ammonites are probably compressed externally, and existing only as casts, are not easy to study with a view to the determination of the species. If there is any truth in Ammonite Zones, that is to say, in particular species being confined to particular zones, it is rather surprising that names applied to Lower Chalk forms, such as *A. Lewisiensis* and *A. peramplus*, should also be quoted for Ammonites in such high beds as the Margate Chalk. It is true that in extreme old age indifferently preserved specimens of large Ammonites, occurring as casts in calcareous beds, have a strong family likeness.

The *Ammonites leptophyllus* of Sharpe, quoted as occurring in the Upper Chalk of Brighton, Ramsgate, Greenhithe, &c., is probably the nearest to, and may actually be the same as the Margate species. "This species reaches a diameter of more than $2\frac{1}{2}$ feet; in shape it is discoidal, flattened at the sides, and rounded at the back." (Pal. Soc., "Chalk Cephalopoda," p. 48). This description answers roughly to the specimen seen in the cliff. The diameter of the outer whorl of this specimen must have been upwards of three feet; many fragments of the middle whorl were

obtained, and also a portion of the little inner whorl with some of the shell on, a rare circumstance in the Chalk. This inner whorl, which is only in a fragmentary condition, has the back very round, and the sides much compressed, with faint indications of numerous costæ of little elevation barely reaching the centre of the back. The figure given by Sharpe (Pal. Soc., "Chalk Cephalopoda," plate xxii.) might very well represent the middle age of such a specimen. Much interest naturally attaches to these Ammonites, which occupy the highest position of any members of that great genus, so characteristic of the Secondary rocks. On or about this horizon, in England at least, they seem to die out.

The party then took the train to *Herne Bay*, and hastily inspected the sections between that place and *Reculver* before returning to London. (See Herne Bay and Reculver excursions, p. 57.)

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FOLKESTONE, SANDGATE AND HYTHE.

[At the conclusion of the Easter Excursion of 1885 the members of the Association who were present returned to London from *Sandwich*. *Deal*, however, remains unvisited, and though *Dover* was the scene of an excursion on August 20th, 1863, no record appears to exist of the sections then seen. But *Folkestone* seems to have been the very first place ever visited by the Association, the date of this first Excursion having been April 9th, 1860. In Proc., vol. i., p. 47, it is stated that the party "proceeded at once to the shore, and spent several hours in examining the Chalk, Greensand, and Gault, as exhibited in East Wear Bay, the Warren, and Copt Point, and procured several specimens of the characteristic fossils." The succeeding excursions to Hythe and Folkestone took place in 1864, 1865, and 1866, during the period when no Pro-

ceedings were issued; their details consequently remain unrecorded. Excursions to Folkestone and the neighbourhood are, however, chronicled in the Proceedings, one in 1870, another in 1876, and a third in 1883. As the account of the last of these is best adapted to serve as an introduction to this district it is here given first.]

EXCURSION TO HYTHE, THE N.E. CORNER OF ROMNEY MARSH, SANDGATE AND FOLKESTONE.—MARCH 26TH AND 27TH, 1883.

(*Directors*—H. B. MACKESON, F.G.S., and W. TOPLEY, F.R.S.)

(*Report by* W. TOPLEY).

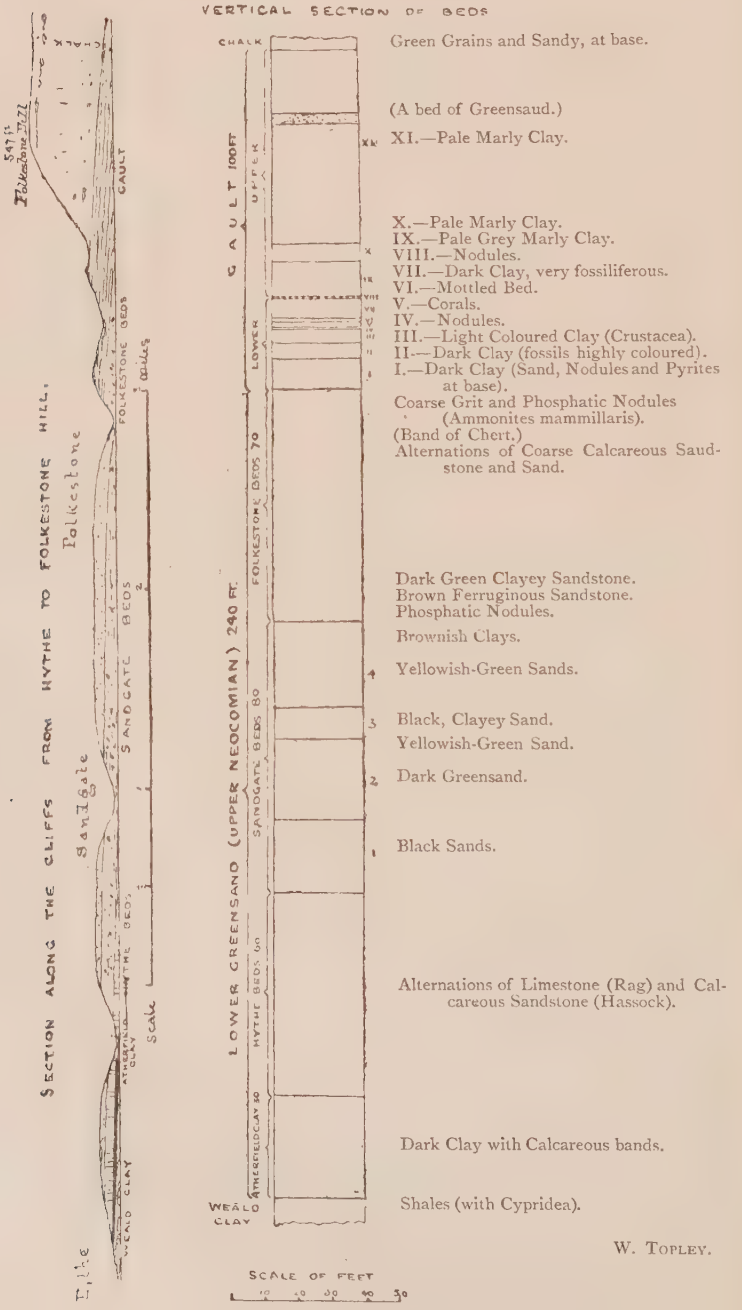
(*Proc.*, *Vol.* viii. *p.* 92.)

MONDAY.—The party assembled at Westenhanger Station and walked thence southward to Lymne, which stands on the brow of an old cliff overlooking Romney Marsh. The summit is capped by Hythe Beds: the slopes are formed of Atherfield Clay and Weald Clay. Landslips are frequent along the face of this cliff, and to these the destruction of the old Roman Castle has been attributed.

From Lymne the old shingle "fulls" at the north-east corner of Romney Marsh can well be seen. As each "full" marks the high-water line at the time of its formation, the history of a shingle beach can sometimes be easily read. The oldest "fulls" here are those furthest west; these run nearly at right angles to the existing coast-line, pointing towards Lymne. They must once have stretched well out to sea, and probably they then curved round to the south and south-west, protecting this part of the Marsh from the sea. The sea has since worn away the S.E. part of this old shingle bank, and the Marsh would be under water at every high tide but for Dymchurch Wall. The ancient *Portus Lemanis* is by some antiquaries placed at Lymne, and here some also place the outlet of the Rother (Limen). But there is no evidence of any old river along the northern side of the Marsh; the "fulls" previously mentioned mark an inlet of the sea, but not necessarily a river-mouth. The Limen probably ran out towards Romney.

Passing through Pedling Green, and over the hill to the N.E. of this, on which is a fine British Camp, the party reached the cuttings of the new branch railway to Hythe. The dark sandy

FIG. 31.—*Sections illustrating the Geology of Hythe and Folkestone.*



W. TOPLEY.

clays of the Sandgate Beds are well seen, and also the sands of the Folkestone Beds. The exact position of some buff-coloured sands which come between them is not evident. Probably they mostly belong to the Folkestone Beds, but the beds differ somewhat in character from those of the coast, which are represented on the accompanying section. (Fig. 31.) After inspecting Saltwood Castle the walk was continued to the quarries N.E. of Hythe, where numerous fossils from the Kentish Rag were obtained. The Atherfield Clay was seen in place at the bottom of the quarries, and on the slope of the hill a slipped junction of the Wealden and Atherfield could be observed since a cutting to show it had been prepared by Mr. Mackeson.

A visit to Hythe Church brought the first day's excursion to an end. In the crypt of the church there is a large collection of bones and skulls, the history of which is unknown. The Vicar (Rev. P. G. Hall, M.A.) explained these, pointing out the peculiarities of some typical examples of skulls.

Tuesday.—This day was devoted to an examination of the cliffs between Hythe and East Wear Bay. A detailed section, compiled chiefly from the descriptions of F. G. H. Price, is given in Fig. 32, and therefore need not be repeated here. The various divisions were pointed out by John Griffith, of Folkestone.

In front of Shorncliffe the junction of the Atherfield and Wealden can be seen at the lowest tides. The general dip of the strata here is a little to the east of north; as the coast line runs a little north of east, higher beds successively come to sea-level as we pass eastward. In this way all the members of the Lower Greensand Series are crossed. West of Folkestone the cliff is much slipped, and natural sections in place are not numerous.

After a break for luncheon at Folkestone the walk was resumed eastward to Copt Point. The Junction Bed of the Gault and Folkestone Beds is here well seen, with its phosphate-nodules, and peculiar Ammonites. The various divisions of the Upper Gault were also examined. A stormy afternoon somewhat interfered with the remainder of the programme; but a few walked along the undercliff, and, under the direction of Prof. W. Boyd Dawkins, examined the Chalk brought out of the Channel Tunnel.

EXCURSION TO SANDGATE AND FOLKESTONE.

JUNE 10TH, 1870.

Director—F. G. HILTON PRICE, F.G.S.

(*Report by* THE DIRECTOR.)

(*Proc. Vol.* iv. *p.* 554.)

ALIGHTING at the Shorncliffe Camp Station the party proceeded along the Sandgate Road towards the shore, passing over the high ground above Sandgate, which is composed of the Folkestone Beds of the Upper Neocomian bed No. 3 of Price's section, (see paper on the "Lower Greensand and Gault of Folkestone," Proc. Geol. Assoc., vol. iv. p. 139.)

Having arrived on the shore the undercliff was examined, where the junction between bed No. 3 and bed No. 2 was plainly seen, showing the calcareous gritty beds reposing on the dark greenish "hassocky" beds of No. 2 and No. 1. Proceeding towards the turnpike on the Lower Sandgate Road, the opportunity was afforded of inspecting the Sandgate Beds of the Upper Neocomian, coming on gradually and just below the turnpike, and of examining the base bed of the Sandgate series (the *Natica sulcata* one), all of which beds dip N.N.E., therefore as the party walked eastward they gradually came upon higher formations. Many pieces of pyritized wood were collected in bed No. 1 of the Sandgate series. The whole of the upper cliff from Sandgate to Folkestone Harbour is chiefly composed of the Third Division of the Folkestone Beds of the Upper Neocomian, the Gault coming on just above the harbour. The Director pointed out the position of the "Elephant Bed," at the Battery, at the eastern corner of the West Cliff, none of which is now visible, it having been mostly dug out when the Battery was constructed.

After a short explanation of the fine cliff section of the Upper Neocomian series, with the Gault capping it, the members walked down to the shore to examine the Folkestone Beds of the Upper Neocomian, so well shown at this point. Owing to the continued prevalence of westerly winds the greater portion of the Sandgate Beds were buried in sand; only the upper part of bed No. 4 of that series was seen *in situ*. At low spring tides the whole of the Sandgate Beds may be seen near the harbour, together with the one of *Natica sulcata* (bed No. 1), which receives its name in consequence of the abundance of that shell. The whole of

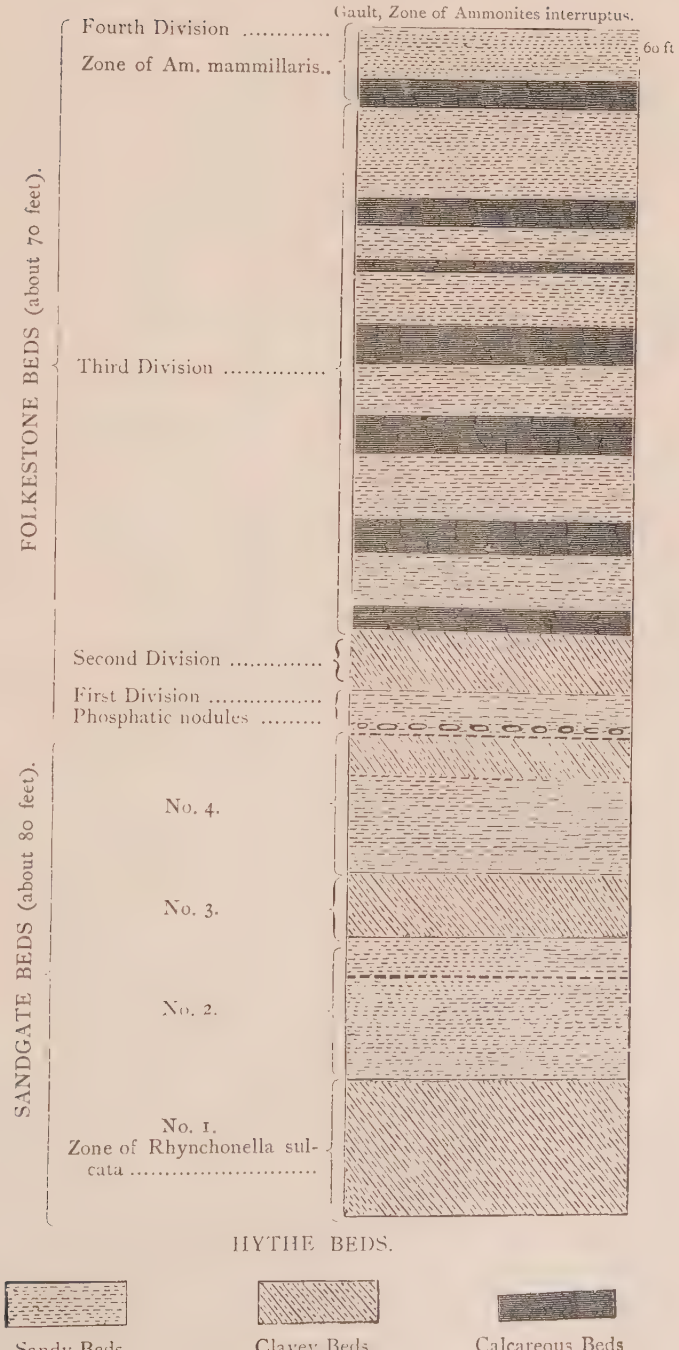


FIG. 32.—SECTION OF UPPER NEOCOMIAN BEDS, FOLKESTONE.

the Folkestone Beds, however, were well examined; these beds gradually dip away towards Copt Point. Many of the members collected a few fossils, and saw many fine specimens of *Exogyra* and *Pseudodiadema*, which owing to the hard nature of these beds they were unable to obtain. The Director pointed out the various zones, and showed the position of the *Ammonites mammillaris* zone in the cliff, the Junction Bed between the Upper Neocomian and the Gault, with the sulphur-band of the zone of *Ammonites interruptus* resting upon it. As Copt Point is turned, these beds are hidden beneath the sea, and the beds of the Lower and Upper Gault, which form the cliff at this point, become more accessible.

In East Wear Bay the Gault beds are no longer *in situ* as at Copt Point, for, owing to frequent landslips, they have been thrown down, and form the floor of the sea-shore. It being low water at the time of the visit, the members were able to examine the lithological and palæontological characters of the various zones, which were explained by the Director. John Griffiths, the well-known fossil collector of Folkestone, disclosed with his pickaxe the richness of the formation, and many typical fossils were collected.

Having passed over the Gault, Mr. Price pointed out the junction between the Upper Gault and the so-called Upper Greensand, which rests conformably upon the Gault, with a few pipings of the dark-green marly sand passing down into the marly beds of the Upper Gault. This deposit is only about fourteen feet in thickness here, and passes gradually into the Chalk Marl, the green grains continuing upwards for several feet. The Upper Greensand is poor in organic remains; the Chalk Marl, on the contrary, is very fossiliferous, and is about ten feet in thickness.

EXCURSION TO FOLKESTONE.—18TH JUNE, 1870.

Director—Prof. J. MORRIS, F.G.S.

(*Proc. Vol.* ii. *p.* 41.)

ON arriving at the harbour pier a survey was taken of the chief points of interest along the coast to right and left of Folkestone. The fine Chalk cliffs forming the northern boundary of East Wear Bay, rising at Folkestone Hill to a height of 566 feet; the outcrop of the soft clay beds of the Gault, and the consequent sudden recedence of the coast; the rise of the sands and stone-beds of the Neocomian strata from beneath Copt Point, and their con-

tinuance to and west of the town of Folkestone, were all matters of remark ; while the former existence and position of a gravel-bed containing the remains of extinct mammalia—*Elephas*, *Rhinoceros*, etc.—on the high ground above the harbour, were noted.

The strata first examined in detail were some dark-greenish sub-argillaceous sands, known as the Sandgate Beds, which rise on the shore at a short distance west of Folkestone. The low under-cliff which skirts the shore from Folkestone nearly to Hythe was shown to owe its origin to the presence of these beds, which, from their retention of water and slight coherency of structure, have caused the frequent subsidence of the beds above. These greenish beds, it was observed, contain sulphur, iron-pyrites in minute grains, and a large proportion of silicate of iron. Unlike the sands above, they do not effervesce in acid.

The sands and silicious sandstones of the Folkestone Beds above were next examined, and proved to be highly interesting. Sandy conglomerates, containing rounded fragments of quartz, white or grey, often stained to a greenish colour ; fragments of quartzite, jasper, and flinty slate, mingled with small phosphatic nodules and casts of shells, were seen to alternate with soft marly beds, containing an abundance of fossils. The stone beds at a higher level, ranging upwards almost to the Gault, were shown by Prof. Morris to consist, in great measure, of the remains of sponges. This was best seen beneath the cliffs to the east of Folkestone ; the huge slabs of stone just above tide-mark being in many places literally made up of sponges, exhibiting in the weathered cavities left by the decomposition of the more ramose varieties a perfect network of silicious spiculæ. Sections showing the passage of the Neocomian sands into the Gault were next examined, the chief points observed being the gradual increase of argillaceous matter in the sands when approaching the Gault ; the occurrence of a band of phosphatic nodules, associated with *Ammonites mammillaris*, about three feet beneath the Gault ; and the abundance of pyritized coniferous wood contained in the nodular phosphatic bed at the base of the Gault itself. Evidence of the constant slipping forward of the Gault over its own basement bed was in places very apparent.

[The *Dungeness* corner of Kent was visited on June 14th, 1886 (Whit Monday). The party slept at *Hastings*, and the next day's excursion was to *Rye*, *Camber Castle*, and *Winchelsea*. A full report will be found in the Proc., vol. ix. p. 544.]

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SURREY.

[As in dealing with the excursions to various parts of Kent it seemed best to begin with places near London, and afterwards to treat of the more distant localities, the same plan has been adopted in the main with regard to Surrey. The excursions, however, in the country due south of Croydon are so placed as to form a continuous series with others in Sussex.]

EXCURSION TO CROYDON, SHIRLEY, AND ADDINGTON.—MAY 7TH, 1881.

Directors JOHN FLOWER, M.A., F.G.S., J. LOGAN LOBLEY, F.G.S., and H. M. KLAASSEN, F.G.S.

(*Proc. Vol.* vii. *p.* 145.)

THE members of the Association left East Croydon Station, and proceeded eastward along the Upper Addiscombe Road, passing over the extreme western edge of the Oldhaven Beds, and a

small outlier of London Clay, extending northward from Park Hill. The sands of the Oldhaven series were well seen in one or two excavations recently made in digging foundations for new houses.

Near the southern end of Ashburton Road the party examined, by the kind permission of the occupier of the land, Mr. H. Johnson, two remarkable springs in the side of the hill on the south side of the road—one at a point about thirty feet, and the other about forty feet above the level of the road. The former of these, which is by far the larger of the two, is about 255 feet above the sea level. It has hollowed out for itself a considerable basin in the hill-side, which has probably been increased artificially, and the stream flowing from it has cut out a considerable valley for itself. These features were here pointed out by Mr. Flower, who also explained the general structure of the hill, and of the Oldhaven and Woolwich and Reading Beds of which it was composed. He also stated that there were numerous similar springs along the northern side of this hill, forming some of the sources of the Wandle and the Ravensbourne. The general opinion is that these springs arise at points where Clay Beds, dipping to the north, come to the surface of the ground on the side of the hill, and there discharge the water absorbed by the large masses of overlying Pebble Beds,

The party then proceeding towards Shirley House, the course of the watershed-ridge, here very broad and flat, dividing the basin of the Wandle from that of the Ravensbourne, was described by Mr. Flower. He also pointed out a spot *on* the watershed-ridge, in a ditch, about forty yards from the Stroud Green Road, where, in winter, a spring rises, from which the water flows eastward into the Ravensbourne, and westward into the Wandle.

After inspecting another fine spring and a small lake the party proceeded to the Addington Hills, where the section of the lower beds of the Oldhaven series at the back of the Sand-Rock Hotel was inspected, and described by Mr. Lobley, as also a pit excavated in the upper beds of the Oldhaven series.

The Addington Hills form the northern escarpment of the Oldhaven and the Woolwich and Reading Beds; the former here attain a height of nearly 500 feet above the sea level. Attention was particularly called to the small valley immediately at the foot of the hills, cut down into the Chalk, and to the still larger valley between that and the South Norwood Hill, which is formed

in the London Clay, the two valleys being, together, about four miles across. Mr. Flower suggested that probably this was once the valley of the ancient stream which came down the valley from Merstham: while the deep valleys which run up into those hills were caused, in times long past, by the action of springs similar to those already visited. The watershed between the Wandle and the Ravensbourne crosses these valleys nearly at right angles.

By the kind permission of the Archbishop of Canterbury Addington Park was next visited. A small lake fed by springs from the Pebble Beds, and situated in a deep valley cut out of them was examined and described by the Directors, and the party then moved on to the Pinetum, where were seen some very fine specimens of *Abies Douglasi*, *A. Menziesi*, and *Pinus nobilis*. The "Fir Mount," overlooking Addington village, and the site of a hunting seat much used by King Henry VIII., was the last point of special interest in the Park. From here fine views were obtained, embracing the high grounds of Worms Heath, four miles distant: these are capped with Pebble Beds, no doubt once continuous with those in Addington Park.

Proceeding down the steep face of the escarpment to Addington village, situated on the Chalk, the party returned home by the road on the southern side of the park. In the beautiful lane between Heathfield and Ballards, the Wandle and Ravensbourne watershed was again crossed. At the Ballards Farm two remarkable blocks of sandstone, believed to be Sarsen stones, and lying on the Chalk, were examined by permission of Mr. Chas. Goschen. From here the party returned, across the fields, to the East Croydon Station.

[There have since been two excursions to *Croydon*, the object of both of them being to inspect the *Penn Hill* section on the new railway from *South Croydon* to *Woodside*. The first took place on July 1st, 1882, Mr. H. M. Klaassen being Director; the second on June 2nd, 1883, the Directors being Prof. John Morris and H. M. Klaassen. Full accounts of this section are given by Klaassen (Proc., vol. viii. pp. 220-248, and vol. xi. p. 404), to the first of which is added an Appendix by F. T. Newton, "Note on a New Species of Perna from the Woolwich Beds," and a "Note on Corylhodon Remains from the Woolwich Beds of the Park Hill Section, Croydon" (pp. 248-254). The following brief details are extracted from Mr. Klaassen's papers, to which the reader desiring fuller information is referred.]

FIG. 33.—PERNA CROYDONENSIS, E. T. NEWTON, FROM PARK HILL, CROYDON.

From the Paper "On a Section of the Lower London Tertiaries at Park Hill, Croydon," by H. M. Klaassen, F.G.S. (Proc., vol. viii. p. 226.)

"Park Hill Section, on the Woodside and South Croydon Railway, extends from the Upper Addiscombe Road, Croydon, to the footpath bridge near Coombe Road. Its length is 3,593 feet, of which 1,254 feet are tunnelled, as shown on the diagram (Fig. 35) by the letters *n—n*; and there are three cuttings, the south, central, and north.

"In July, 1882, the Association examined the South Cutting. It was seen under most favourable circumstances: the weather had been dry for some time, the Mottled Clay stood firm at an angle of 45°, having been dressed to the same slope as the underlying sandy beds, and the neatly trimmed banks displayed the variously coloured strata with such admirable definition that the divisions in the section were seen at a glance. A rainy season

has since greatly altered the appearance of this cutting, and its brilliancy only exists as a pleasant remembrance to those who have seen it.

"Before entering the cutting we observed, from the footpath bridge (at *R.*, below *S.S.W.* in the section Fig. 35), on our right, the Oldhaven outliers of Addington Hills and Croham Hurst, covered with heath, gorse, broom, and firs, and we noticed that the railway at Park Hill cuts through a ridge which, shaped by denudation, lies between the Chalk and the London Clay. The highest point at Park Hill is 282 feet; its well-marked Tertiary escarpment overlooks, with a southward face, the dip-slope of the Chalk, which attains a height of 797 feet at Woldingham; and at Sydenham, three miles north of Park Hill, the London Clay is 367 feet above the sea level."

From the footpath bridge we passed into the railway cutting and examined the Thanet Beds, the lowest strata exposed, and, as the section (Fig. 35) shows, traversed higher and higher beds during our northward progress. The thickness of all these beds is given below.

Vertical Section of the Lower London Tertiaries at Park Hill.

		Greatest thickness.	
		feet.	
	Brown and grey laminated Clayey Sand	10	
	Grey Sand	24	
	Pebble-bed	15	
	Hard white Shell-bed	10	
	Blue Clay with lignites	10	
	Mottled Clay	21	
	Lavender-coloured sandy Pebble-bed 1 ft. 6 in.		
Bottom-bed.	Green Sand 3 „ 0 „		
	Greenish-brown Sand 6 „ 8 „		
	Grey Sand 2 „ 0 „		
	Brown Clayey Sand 2 „ 0 „		
		15	2
	Thanet-beds	38	0

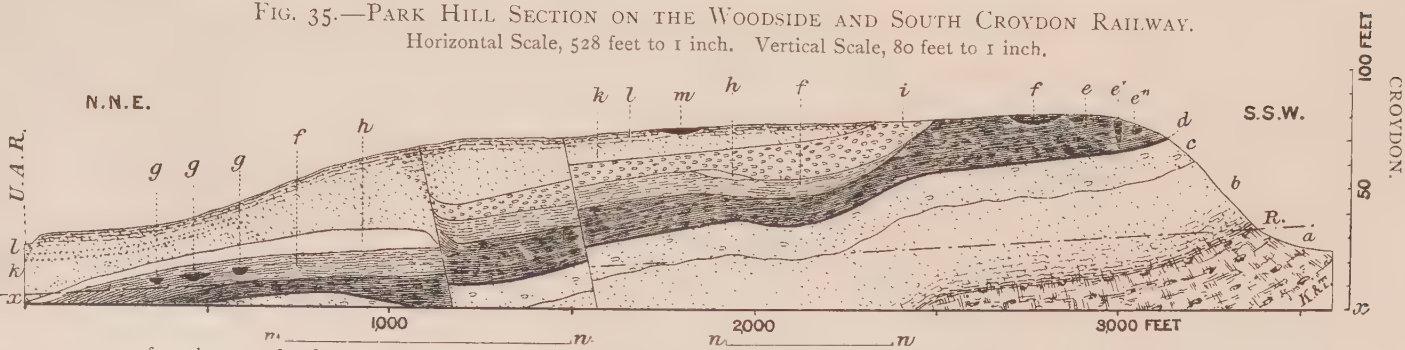
FIG. 34.—GENERAL SECTION FROM THE CRYSTAL PALACE OVER PARK HILL TO OXTED.

Horizontal Scale, 2 miles to 1 inch. Vertical Scale, 1,800 feet to 1 inch.

a. Weald Clay ; *b*, Lower Greensand ; *c*, Gault ; *d*, Upper Greensand ; *e*, Chalk ; *f*, Woolwich and Reading Beds ; *g*, London Clay.

FIG. 35.—PARK HILL SECTION ON THE WOODSIDE AND SOUTH CROYDON RAILWAY.

Horizontal Scale, 528 feet to 1 inch. Vertical Scale, 80 feet to 1 inch.



x 200 feet above sea level.
a Chalk.
b Thanet Beds.
c Woolwich and Reading Bottom-bed.
d Lavender-coloured sandy Pebble-bed.
e Mottled Clay (fluviatile).
e' e'' Pockets.
f Blue Clay (estuarine).
g Lignite-beds.
h Hard white Shell-bed.
i Pebble-bed.
k Grey Sand.
l Brown and grey laminated clayey Sand.
m Drift.
n n Tunnels
R. Railway Level. *U.A.R.* Upper Addiscombe Road.

EXCURSION TO RIDDLESDOWN AND CROYDON.

APRIL 17TH, 1875.

Directors—CALEB EVANS, F.G.S., and J. LOGAN LOBLEY, F.G.S.

(*Proc. Vol.* iv. *p.* 282.)

LEAVING the train at Caterham Junction Station members had but a few yards to walk to the fine section of the Upper Chalk at the western extremity of Riddlesdown. Gradually ascending the Down, while proceeding eastward, the members attained an elevation which enabled them to obtain fine views of a portion of the Chalk country, with its gently swelling hills and riverless valleys, formed by the denudation of the North Downs.

On reaching the mouth of the half-made tunnel of the abandoned Surrey and Sussex Railway the geologists immediately entered the excavation, and examined the Chalk there exposed with its nodular and tabular flint. Mr. Caleb Evans, who has, from his observations of the various Chalk sections of this neighbourhood, obtained sufficient evidence to enable him to divide the Chalk into palæontological zones, explained that the beds here exposed are the Upper Kenley beds, containing an assemblage of fossils markedly different from the fauna of the Purley beds, higher in the series, and also from that of the immediately underlying Lower Kenley beds. While *Inoceramus Cuvieri* is wanting in the Upper Kenley beds, it is present in both the Purley beds and the Lower Kenley beds. *Holaster planus* and *Micraster cor-bovis* occur in the Lower Kenley beds, but are not found in the Upper, which appear to be characterised by the abundance of three of the best-known of Chalk species, *Micraster cor-anguinum*, *Echinocorys scutatus* (*olim Ananchytes ovatus*), and *Spondylus spinosus*.

In his paper "On some Sections of Chalk between Croydon and Oxted" (8vo, *London*, Geol. Assoc., 1870), Mr. Evans fully describes this and other sections exposed during the formation of the railway; and the following list of species from the Upper Kenley beds of this locality is given :—

PROTOZOA—
Cephalites campanulatus, Smith.
Brachiolites convolutus, Smith.
ECHINODERMATA—
Echinocorys scutatus, Leske.
Micraster cor-anguinum, Gmelin.
Cidaris vesiculosa, Goldf.
POLYZOA—
Desmeopora semicylindrica, Rœm.
Flustra.
Hornera or *Homœosolen*.
BRACHIOPODA—
Terebratula carnea, Sow.
" *semiglobosa*. Sow.
Rhynchonella limbata, Schl
" *Mantelliana*, Sow.
Crania Ignabergensis, Retz.
LAMELLIBRANCHIATA—
Pecten quinquecostatus, Sow.
Spondylus spinosus, Sow.
PISCES—
Lamna.

The summit of the Down was then crossed, and following a lane the party struck the London and Brighton road at the picturesque grove called "Purley Oaks," near to which is the Chalk quarry in which was found a granite boulder, possibly deposited on the bed of the old Chalk sea by an iceberg from the ice-capped lands of the Cretaceous epoch [or dropped from the roots of a drifting tree.]

A mile walk brought the members to the outskirts of Croydon, where the Cretaceous rocks give place to the Tertiaries of the London Basin, the southern edge of which is here found. Near to the conspicuous tower of the Croydon Waterworks, a large excavation affords a good exposure of the junction of the Chalk with the overlying Thanet Sands. This was the last section visited, and the party then took train to London.

EXCURSION TO CROYDON AND RIDDLESDOWN.

SATURDAY, JUNE 19TH, 1880.

Director—J. LOGAN LOBLEY, F.G.S.

(*Proc. Vol.* vi. *p.* 372.)

ON arriving at East Croydon Station the members of the Association were met by Mr. John Flower. The well-known extensive gravel-pits in Fairfield were first visited, and the fine sections of Valley gravels here exposed were carefully inspected. The Director and Mr. Flower explained the sections, and drew attention to the presence of the Oldhaven pebbles, so abundant now at Shirley and Croham Hurst, and to the course of the Wandle having changed so considerably as to leave here high and dry about twenty feet thickness of its old deposit. Mr. Flower was not aware of any organic remains having been found here, but at Thornton Heath an elephant's tusk, preserved by a coating of clay, had been obtained.

The underlying Woolwich and Reading beds are not now exposed as formerly in Chichester Road, but the presence of their clay-beds is indicated by springs and by the lake in the grounds of Park Hill House. By the kindness of Dr. Strong, of Croydon, the party were enabled to assemble on the top of the Water Tower. The day being fine the physical features of the district were seen to advantage; the hills of Shirley and Croham Hurst, and the Banstead Chalk Downs rising boldly to the south and west, and on the north the great valley of the Thames running from west to east.

At the foot of Water Tower Hill a very interesting section shows the erosion of the Thanet Sands almost to a feather edge, resting as usual on the Chalk capped with green-coated flints. There is thus seen the extreme southern edge of the London Tertiary Basin.

Croham Hurst, a mile to the south, was next visited. The summit of this hill, 477 feet above the sea level, is an outlier of Thanet and Oldhaven beds, the well-rounded black pebbles of which, by rolling down, cover a considerable part of the steep slopes. So steep indeed is one side that it is called Breakneck Hill. Thence the party made their way by the Brighton road to the Chalk-pit opposite to the "Royal Oak," famed for the granite boulder once found in it, and attributed to ice action in the Cretaceous Period.

The party subsequently proceeded, by way of Purley, to Riddlesdown, skirting the fine Chalk valley of Kenley, along which, after exceptionally wet seasons, the Bourne river flows. After the sections of the Chalk exposed in the excavations along the hill had been seen the train for London was taken at Warlingham Station.

[An excursion to *Caterham* and *Croydon* took place in 1869, during the period when Proceedings were not issued. The next visit to *Caterham* was on the occasion of an excursion to *Caterham* and *Oxted*, April 19th, 1870, of which there is a brief report (Proc., vol. ii., p. 28).

An excursion to *Caterham Junction* and *Riddlesdown* took place on July 1st, 1871, the Director being J. Logan Lobley. A report of it may be seen in Proc., vol. ii., p. 274; but as the country visited is fully described in the account of the excursion to *Riddlesdown* and *Croydon* on April 17th, 1875, with the addition of a list of the local fossils, no extracts from the report of the excursion of 1871 are necessary.]

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Maps.—Ordnance Survey. Geological. Sheets 6 and 8. 8*s*. 6d. each.

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Books.—W. Whitaker, Geology of London (Geol. Surv.), 8vo, *London*, 2 vols. 1889. 11*s*.

C. Evans, On some Sections of Chalk between Croydon and Oxted, etc. 8vo, *London* (Geol. Assoc.) 1870.

1*s*. [In this paper there is a continuous section through Purley, Riddlesdown, Whiteleaf, Warlingham, Marden Park, and Oxted ; but it is too large to reprint in this volume.]

J. Morris, Lecture on the Geology of Croydon. 8vo, *Croydon* (Croydon Microsc. Club). 1875. 1*s*.

H. M. Klaassen, On the Pebbly and Sandy Beds overlying the Woolwich and Reading Series on and near the Addington Hills. *Proc. Geol. Assoc.*, vol. xi. 1890.

See also Geological Record, 1880-1884, vol. i. index, p. 504.

EXCURSION TO KEW GARDENS, RICHMOND, AND KINGSTON HILL.

SATURDAY, JUNE 12TH, 1880.

Directors—SIR JOSEPH D. HOOKER, C.B., F.R.S., and J. LOGAN LOBLEY, F.G.S.

(*Proc. Vol.* vi. *p.* 370.)

SIR J. D. HOOKER conducted the party through several of the houses and the most interesting parts of the gardens.

On leaving the gardens Mr. Lobley conducted the party by Richmond Green, the old tilting yard of the great historical palace of Richmond, or Sheen, as it was in olden times called, to the "Hill," where, with the Survey maps of the district spread on the ground, the physical features of the portion of the Thames Valley, seen from this commanding eminence, were pointed out. Though the atmosphere was not very clear, the towers of Windsor, marking the commencement of the Western Chalk, were made out, but the elevations of London Clay, on the northern side of the valley, could not be seen. The steep declivity of Richmond Hill, and the somewhat elevated and undulating country on the Surrey side of the valley in this district, are in marked contrast to the broad flat of river gravel forming a considerable portion of the county of Middlesex on the other side of the river. The higher land on the Surrey side is London Clay, covered, for the most part, by High-level Gravels, and in some places by Bagshot Sand, while the low lands of Middlesex present an almost unbroken sheet of Low-level Gravels and Brick-

earths covering London Clay. These Brick-earths are most extensively worked near the Great Western Railway in the neighbourhood of Southall and other places.

Proceeding through the Park a gravel-pit, near the Thatched House Lodge, claimed attention as an interesting indication of the presence of the Bagshot Sand. Another outlier of these beds was passed on Kingston Hill, where an old pottery affords a somewhat unsatisfactory exposure.*

Higher up the hill, and near the "George and Dragon," an extensive excavation displays a very fine section of the High-level Gravel, which was examined with great interest, and explained by the Director, who drew attention to the presence of pebbles derived from various and distant rocks, although the great bulk of the gravel is composed of subangular and rounded flint from the Chalk. Ragstone and chert pebbles from the Greensand are common, while subangular quartz pebbles are by no means rare, and others are met with which are doubtless from Silurian rocks.

References.

Maps.—Ordnance Survey. Geological. Sheets 7 and 8. 8*s.* 6*d.* each.

New Ordnance Survey. Sheet 270. 1*s.*

Stanford's Geological Map of London. 5*s.*

Books.—W. Whitaker, Geology of London (Geol. Surv.), 8vo, *London*, 2 vols. 1889. 11*s.*

W. Whitaker, Guide to the Geology of London (Geol. Surv.), ed. 5. 1889. 1*s.*

[On May 5th, 1888, there was an excursion to view the sections on the new line of railway between *Wimbledon* and *Putney*. See Proc., vol. x. p. 471. The Directors were W. Topley and Oswald M. Prouse.

On May 1st, 1886, an excursion to *Ewell* and *Epsom* took place, H. Hutchins French directing; and on May 29th *Walton Common* and *St. George's Hill* were visited under the leadership of W. H. Hudleston. Both excursions are fully described in Proc., vol. ix., p. 532 and p. 537; for convenience the two figures relating to Walton are here given.]

* Not Bagshot, but top beds of the London Clay, according to Whitaker.

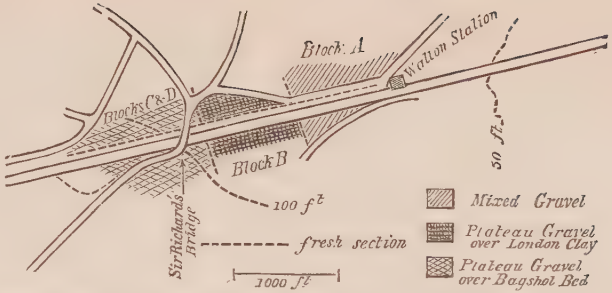

FIG. 36.—SKETCH-MAP, SHOWING THE POSITION OF THE SECTION AT WALTON.

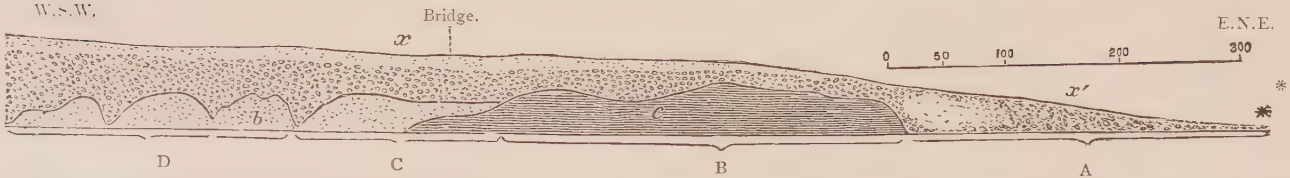

FIG. 37.—GENERALIZED SECTION OF THE CUTTING THROUGH WALTON COMMON, SEPTEMBER TO DECEMBER, 1885.

Total length 1,070 yards: maximum depth about 27 feet. Depth at the Bridge, 24 feet.

Block A extends from Walton Station to where the unaltered London Clay is seen to occur *in situ*, a distance of 313 yards.
Block B extends from this to the point where the Bagshot Beds are first seen *in situ*, a distance of 345 yards.
Block C extends from the above to the point where the Bagshots are first cut through to the level of the line, and the hollow filled up with Plateau-Grave a distance of 165 yards.
Block D exhibits the relations of the Bagshots to the Plateau-Gravel, where the latter is most fully developed, a distance of 247 yards.

* Walton Station. *b* Bagshot Beds. *x* Plateau-Gravel. *x'* Mixed Gravel.
Scale—300 yards. *c* London Clay.

(From the *Quart. Journ. Geol. Soc.* xliii. (1886), p. 147, which see for full details.)

EXCURSION TO EPSOM AND DORKING

MAY 24TH, 1884.

Directors—W. H. DALTON, F.G.S., and H. H. FRENCH, F.G.S.

(*Report by* W. H. DALTON.)

(*Proc. Vol.* viii. *p.* 396.)

ON arriving at Epsom, shortly before noon, the party proceeded to the Downs. Here, at the back of the rifle-butts, they examined a pit in the Upper Chalk, the beds of flint in which served as indications of the amount of dislocation of a fault which throws down the beds about eight feet to the south-east. Several slickensided faces were observable on joint-planes of parallel direction; and, although such surfaces have been attributed to pseudomorphism of aragonite, &c., it was agreed that no such hypothesis was requisite in such cases as the present, where relative movements of the different portions of rock were in evidence. At one point of the fault a vertical sheet of flint had been formed, probably by replacement of chalk in water occupying a temporarily open fissure. Traversing the race-course the party ascended the hill on which stands the village of Walton. The summit of the hill consists of a thin sheet of Thanet Sand, overlaid by crimson mottled brick-earth and gravel. An old brick-yard here was open in 1860, when Whitaker saw a section in the Thanet Sand, eight feet deep, under the brick-earth. Speculations were rife among the party as to the course of the river which formed this gravel and as to the cause of the survival of the Thanet Sand outlier, some maintaining its probable protection by beds locally harder than usual (although the several outliers reach to different horizons of the Lower Tertiary Series), whilst others preferred the hypothesis of a slight synclinal undulation parallel to the general strike of the Chalk and Tertiaries, patches of the latter being preserved in a discontinuous trough ranging for about eight miles, Walton being nearly midway between the extremities. On Walton Heath some exposures of "clay with flints" were visited, and the Directors of the party were pressed, but in vain, to commit themselves, jointly or severally, to one of the many theories of the origin of this deposit. That which attributes it to the solution of Chalk by percolating water *plus* relics of Tertiary beds is the theory which in these days of compromise and tolerance is perhaps the safest. The thickness of the deposit and its

continuous occurrence along the escarpment attest the great denudation which the Chalk has undergone.

From the heath a fine view was obtained of Pebble Hill and Leith Hill, the former being part of the Chalk escarpment close by, whilst Leith Hill is on that of the Lower Greensand several miles to the south-west. Descending the hill by a deep-cut road, whose high banks only showed the Chalk, decomposed into amorphous marl, at intervals, a large pit in the Upper Greensand was reached, where, under a head of Chalk rubble, the Chloritic Marl was seen, highly fossiliferous, overlying the Hearthstone beds, for which the pit is opened. The two divisions are of very similar lithological character, calcareous clayey sand, with abundant glauconite grains, which on a surface bruised by a frictional stroke of the hammer form green streaks. The absence of fossils from the Hearthstone appears to be the only difference noticeable. The Chloritic Marl and the Chalk rubble are carried across the pit on staging, and the Hearthstone is raised vertically by a windlass from the floor of the pit. At a lower level occurs the Firestone, used for furnace-lining, &c., to obtain which slanting tunnels have been carried far in under the hill. This stone has also been used for building, for instance, in Windsor Castle and in Henry VII.'s Chapel, Westminster Abbey.

Passing through Betchworth, the party next entered a large pit in the Lower and Middle Chalk, the Upper Chalk having been denuded back from the escarpment. The local name here is "grey stone," in contradistinction to the white Upper Chalk. Many nodules of iron-pyrites were noticed in the lower part of the pit, generally unaltered within, though oxidised to a rich rust-colour on the surface: in the proximity of joints, however, the oxidation extended deeper, and in small nodules was complete. The chemical action consists in the absorption of oxygen dissolved in percolating water, forming ferric sulphate, which by contact with the surrounding Chalk forms sulphate of lime and carbonate of iron, the latter speedily passing, by addition of further oxygen, into the red peroxide of iron.

Few fossils were obtained from this pit; but in another close by some fragments of fish remains, and some of the characteristic shells, *Terebratula*, &c., were purchased. The elaborate kilns here used for burning the chalk into lime were examined with much interest, and the party then defiled along the narrow winding path known as the Pilgrim's Way (which extends from Alton, in Hants, to Canterbury), to the Brockham brick and firestone-pits, where

the lower beds of the Upper Greensand, and nearly the highest of the Gault Clay, are exposed, though not in continuous section. Neither are fossiliferous, but it may be noted that the upper part of the Gault section was crowded with nodules of "race," segregations of carbonate of lime from the surrounding clay, and that thin veins of fibrous gypsum are formed by the decomposition of pyrites and neutralisation by carbonate of lime, as described above. The Pilgrim's Way on the Gault and Upper Greensand is here bordered almost continuously by yew-trees, whilst east of Reigate, where it passes into the Lower Greensand, the ash replaces the yew, a striking example of the relation between geological structure and vegetation.

The firestone is worked by tunnel, the rock at the mouth appearing to differ in no respect from the Hearthstone previously examined.

After half an hour's walk the Lower Greensand was reached at a mill turned by the Mole, and the coarse ferruginous sandstone was briefly examined. This uppermost division is known as the Folkestone Beds, and its colour is due to peroxidation of its contained iron. A fine section of similarly tinted sand and sandstone is exposed on the railway a short distance further west, but time did not permit of its examination, so the party pushed on to Dorking station.

EXCURSION TO THE GORGE OF THE MOLE, BOX HILL, AND DORKING.—Saturday, July 13th, 1878.

Director—J. Logan Lobley, F.G.S.

(*Proc. Vol.* vi. *p.* 38.)

On leaving the train at Leatherhead the party speedily entered the mouth of the valley or gorge which traverses the North Downs from Leatherhead to Box Hill, and through which the river Mole makes its way on its northern course to the Thames. The northern end of the valley is comparatively open, the bounding hills being of low elevation; but in a little time the gorge becomes more decided, the hills at either side increasing in boldness until the southern end is reached, where Box Hill attains an elevation of about 600 feet. The length of the valley, following its windings, is about five miles, the Chalk being here about four miles in width. This is one of four transverse valleys by which four rivers, draining a large portion of the Wealden area, cross the North Downs. These are, from west to

FIG. 38.—SECTION OF NORTHERN VALLEY OF THE WEALD. (LENGTH OF SECTION ABOUT 9 MILES.)

h'' Tunbridge Wells Sand. *h2* Weald Clay. *h2'* Atherfield Clay. *h2''* Hythe Beds. *h2'''* Sandgate Beds. *h2''''* Folkestone Beds. *h3* Gault. *h4* Upper Greensand. *h5* Chalk.

east, the Wey, the Mole, the Darent, and the Medway.

Proceeding along the eastern side of the river, Norham Park was reached. Through this park the Mole runs for some distance, and in several places along this part of its course some of the water finds an underground passage by what are called "Swallow Holes."

After passing through the village of Mickleham, Juniper Hill was ascended, and striking and beautiful views of the valley were obtained from this hill, so well known from the fact that it is clothed with juniper trees of great size and beauty. The neighbouring Box Hill, at the southern extremity of the gorge, was soon afterwards reached and ascended. The great difference in the vegetation of the two hills is very striking, for while it is difficult to find a box tree on Juniper Hill, it is difficult to find a juniper on Box Hill, which is densely covered with the trees that give to this well-known hill its name. One side of Box Hill forms a part of the escarpment of the North Downs, which is here very steep. Rapidly descending the escarpment, the Upper Greensand was crossed at the bottom of the declivity, and the narrow outcrop of the Gault was passed over, when sections of the Lower Greensand near the mill and railway-cutting, near Dorking, were pointed out by the Director, who then led the way to Dorking station.

EXCURSION TO LEITH HILL AND DORKING.

SATURDAY, JULY 24TH, 1880.

Directors—Rev. Dr. A. IRVING, F.G.S., and Dr. A. C. MAYBURY, F.G.S.

(*Report by* Dr. MAYBURY.)

(*Proc. Vol.* vi. *p.* 393.)

LEAVING the train at Ockley, where Mr. H. Hawkins, who had recently been engaged in mapping the superficial deposits of the district, joined the party, the brickyards near the station were first inspected. The Weald Clay, here exposed, presented its usual characters, being stiff, blue, and weathering red from the peroxidation of its iron. In it were sands, forming a local lenticular mass: they were very finely laminated, and were interstratified here and there with thin bands of clay. The existence of the clay beneath the sands was indicated by the occurrence of water at the base of the section. The strike of the rocks is here E. and W. In passing from this the first pit, in an easterly direction, to the second, Weald Clay of older date was passed over, so that one stood here on the clay which lay under the sandstone in the first section. No fossils, with the exception of some carbonized wood, have been found here, though in the brickfields at Holmwood Cyprides are abundant, thus proving the fresh-water character of the deposit.

The line of march was then through the village of Ockley to Stone Street, where a turn was made to the north along the Causeway. After proceeding for some time on the low-lying, level Weald Clay, the party gradually got on to higher ground and to rocks of later date, viz., the Atherfield Clay (the lowest member of the marine Lower Greensand) and the Hythe Beds which immediately follow.

Having attained the summit of Leith Hill, an elevation of some 970 feet, a magnificent view of the surrounding country rewarded the geologists. The Hythe Beds of Leith Hill are composed of sands and sandstone, with no calcareous matter, but with occasional intercalated silicious bands. The prevailing colour is red, the rocks being studded with green particles of glauconite. It is in the absence of calcareous matter that these beds differ from those of the same age in the Godalming area, where the Bargate-stone, consisting of a calcareous sandstone equivalent to the uppermost portion of the Hythe Beds, is best developed.

On looking southward one sees an abrupt escarpment for about 200 feet, the slope then becomes more gradual, and extends far out into the Weald. The incoming of the clay is revealed by the occurrence of a line of springs, where the sandstone rests on the Atherfield Clay, and the look of the fields and the presence of oaks indicate the same thing as the diminution in the slope of the ground.

Leith Hill and the surrounding district teach us some points in physical geology worthy of note. The area slopes gradually to the north, which slope corresponds with the dip of the beds, viz., about 2° or 3°, and this inclination is well seen in a section due east from the Tower. It forms an extensive tract, cor-

FIG. 39.—SECTION FROM LEITH HILL TO RAMNER COMMON.

o. Clay, with flints, etc.
n. Chalk, with flints.
m. Chalk, without flints.
l. Upper Greensand.
k. Gault.
i. Folkestone Beds. } Lower
g. Hythe Beds. } Greensand.
f. Atherfield Clay.
e. Weald Clay.
* Sea Level.

(*Reduced from the Survey Memoir.*)

responding in general characters with the Bagshot district, and clad with heather, furze, and fir trees. The ground has been sculptured by subaerial denudation, and valleys have been produced whose general direction is at right angles to the strike of the beds, *i.e.*, to the axis of disturbance of the Wealden deposits. In some cases *(a)* they do not cut through the Hythe Beds, *(b)* in others they expose the Atherfield Clay, whilst *(c)* in yet others they make the Weald Clay visible. Hence, in the first case the valleys are dry, in the two latter cases wet or damp. In some instances the denudation has been stopped by a band of harder rock in the Hythe Beds, so that we have a small waterfall comparable with those found in the Isle of Wight, where a hard ferruginous band in the Lower Greensand resists the action of running water in some of the Chines.

On the homeward journey through Cold Harbour the Hythe Beds, Atherfield Clay, and Weald Clay were passed over, for, though we travelled in the direction of the dip, and therefore came

on to rocks of later date, denudation had, in two or three cases, caused lower beds to crop up at the surface.

On nearing Dorking a line of fault, running east and west, was crossed. The *upthrow* is to the extent of 100 feet, and on the south the Weald Clay (from which later deposits have been removed) is brought into juxtaposition with the Hythe Beds. Further evidence of this fault may be had in the fact that on the road to Guildford, beyond the Rookery, and near Wotton, sandstone is at a greater elevation than the Bargate stone, though the latter is on a higher *geological* horizon. The occurrence of this fault has had much to do with the altitude of the Leith Hill area, and has an important bearing on the question of water-supply, because that quantity of the rain which percolates through the Hythe Beds of the area will probably, in addition to leaking out at the junction of the sands and clays, be to a great extent borne to a lower level through the fissure, so that in a well sunk between it and London there might be an absence of the water which fell as rain on Leith Hill.

[Leith Hill was also visited on June 28th, 1890, W. Topley being Director.

On June 25th, 1887, H. H. French conducted a large party to *Gomshall*, *Netley Heath*, and *Clandon*, about midway between Dorking and Guildford. An account of this excursion may be seen in Proc., vol. x. p. 182.]

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[*Guildford* was first visited by the Association in 1869, during the cessation of issue of Proceedings. From a brief record of the event in the *Geol. Mag.* for 1869, p. 331, we learn that the chief object in view was "the examination of the several kinds

of strata forming the hills and vales in the vicinity of *Guildford*, *Shalford*, and *Chilworth*." The leaders were the President (Prof. Morris), C. J. A. Meÿer, and Prof. T. Rupert Jones. The report of the second excursion is given below.]

EXCURSION TO GUILDFORD AND CHILWORTH.

June 1st, 1872.

Directors—Prof. T. Rupert Jones, F.R.S., and C. J. A. Meÿer, F.G.S.

(*Report by* Prof. Jones.)

(*Proc. Vol.* iii. *p.* 93.)

The members met Prof. Rupert Jones at the Guildford Railway Station, and proceeded to examine the section of the Woolwich and Reading Beds just north of the station. This section was described by Prestwich in 1850 (see *Quart. Jour. Geol. Soc.*, vol. vi., p. 260, fig 6), not long after it had been exposed by the railway-cutting. A year ago it was laid bare afresh when the railroad was widened, but already the slipping of the clays has obliterated some points of interest. Traces of the shell-beds, with *Cyrena* and *Ostrea*, from the basement bed of the London Clay, are to be found at the base of the telegraph post, 100 yards south of the road-bridge, and the underlying mottled clays, with a dip of 4° to the north, are easily recognized for about 190 yards to the south, where a small valley (about fifty yards across) has been formed by denudation out of the sands and lowest green sandy clays resting on the Chalk, which forms the northern foot of the Hog's Back or Surrey range. Here the Chalk is seen to be traversed in every direction with fissures, often slickensided; some empty, some filled with vein-flint, and some with loamy stuff. Nodules, and occasional thin laminæ of flint, follow the dip of about 6° to the north, and are often in a crushed condition. Bands of marly Chalk also lie on the same plane. Some Echinoderms were met with.

Mr. Godwin-Austen, F.R.S., now joined the party, who next visited the much larger excavation of the Chalk at the entrance of the railway-tunnel. Here the dip, well marked by flints and marly bands, is about 12° to the north. Fossil sponges, echinoderms, *Inocerami*, &c., abound in this pit. The usual chalcedonic and quartzy interiors of hollow flints attracted notice, and Prof. Rupert Jones drew attention to facts that seemed to him to bear evidence of flint being a pseudomorph after Chalk. Leaving this

instructive section, and following the road out of Guildford towards Godalming for nearly a mile, the party turned off to the right along a country road parallel with the Chalk range, but separated from it by the deep valley cut along the strike of the soft Gault. This led them to a quarry in the Lower Greensand on the escarpment overlooking the pathway to Losley. In this section of those Neocomian beds known as the Bargate stone, the water-worn sand of quartz, ironstone, lydite, and hard green silicates is so largely mixed with calcareous fragments (the *debris* of shell-beds, polyzoan reefs, &c.), that it is here and there cemented together compactly enough to serve as a building-stone and for road-metal. Mr. Meÿer, working here, has made this quarry classic ground, and on this occasion he kindly pointed out the several species of *Terebratula*, *Avicula*, *Polyzoa*, and other fossils that are peculiar to this formation, or that link it with that at Upware and other places. Especially he directed attention to the horizon at which he obtained an unrolled tooth of *Iguanodon*, indicating the existence of this great Dinosaur at perhaps the latest period to which any of its remains are as yet known to belong. The false-bedding of the sands, due to the southward set of prevalent tides and currents, and the probable origin of their materials from the old palæozoic ridge or shoal, as taught by Godwin-Austen, who first made out its existence and history, were also studied. The formation of the escarpment was also noticed by Mr. Meÿer. The geologists then retraced a portion of the route until they crossed the Portsmouth road at the foot of St. Catherine's Hill, and then went down to the ferry, where St. Catherine's Spring issues beneath the hill from a little cave in the red orange-tinted sand, draped with deep green mosses. The ferry-boat placed them in view of the picturesque cliff of rich-tinted sand, bearing St. Catherine's ruined shrine a-top, on the right hand, whilst the flat alluvial valley of the Wey, grassy and wooded, led away towards the white cliffs of quarried Chalk opposite.

The Guildford gap, for thirty feet at least, has been found by boring to be occupied by bouldered Chalk, and other detritus, due to the destructive and yet conservative agencies of nature. Threading the grassy paths of Shalford Park the tourists came to the turnpike-road, and entered a lane on the soft irony beds of the Lower Greensand, and followed their strike along the woods, with the red-yellow sands of the hill on the right, and the Gault valley on the left, for about a mile, until a short field-lane, crossing

the Gault and Upper Greensand, led into the Chalk-marl quarry below Warren Farm. There, as Mr. Meÿer explained, the loss of the clay-beds (Gault) from below by their having been squeezed out along the southern side, had allowed the hard marl-rock to subside inwards suddenly at the escarpment, and to rest at a high angle (70° and more), whilst the Chalk of the hill-range above dips only five or six degrees. As the hard rock-bands here quarried for lime are followed end-on along the "strike," open to day, the backs of lower beds form one side of this deep, narrow pit; and the truncated edges of these somewhat bent and much fissured strata warn the instructed eye of the danger of standing either below them or above them, lest either rain or drought should detach their clinging surfaces on the sloping bed plane. The down-turned edges of the strata, under the sward of the hill-side, are also observable, having been bent over and downwards by the combined action of rain, frost, and snow, on the slope of the hill. Large Ammonites and Nautili are the chief fossils met with here; but *Pecten Beaveri* and *Terebratula* are also found. In an old excavation in the lane *Siphonia* has been found in the representative of the Upper Greensand, which is underlaid by dark green sandy clay and Gault, turned up at a high angle (and probably squeezed out) in the breadth of a few yards, before the iron-sands are reached on returning to the hill-side.

Once more continuing the walk along the woods, and crossing the picturesque transverse slopes and gullies leading down into the fertile Gault valley on the left, the party came to the foot of St. Martha's Hill, or St. Martyr's Hill, for martyrs (Mr. Godwin-Austen said) were burnt on the hill by the pagan Saxons; and St. Martha was one of these Romano-British sufferers. Before mounting this hill of sand, seamed irregularly with ironstone, some of the party descended the Halfpenny Hatch Lane, leading down towards the East Shalford bottom, and saw a section of sands and calcareous sandstones, with fuller's earth bands and pebbly beds, similar to that in the quarry on the other (western) side of Guildford.

On the hill-top is St. Martha's Church, enshrining (it is said) the spot of martyrdom, and including some of the structure of the Roman watch-tower. The wide stretch of Tertiary beds on the north, and the broad expanse of Wealden beds on the south, were pointed out. On this elevated ground Prof. Rupert Jones spread his diagrams and maps of Jurassic and Cretaceous seas and lands; whilst Mr. Godwin-Austen told how the underground

structure of south-eastern England is connected with that of the Boulonnais, Belgium, the Ardennes, and Westphalia; and how the folds and ridges of palæozoic rocks which, in those countries, bear up, either at the surface, or just beneath the Chalk or the attenuated Oolites, valuable coal-beds, are continued through, in a broad sweeping line, underneath parts of Surrey, Kent, and Sussex, until visible again near Frome, in the Bristol coal-area, in North Devonshire, South Wales, and the south of Ireland. The old faults and fissures affecting this linear tract of old strata had long before the Coal-period raised and depressed the lands and sea-beds; and as a great spur of the old Scandinavian lands, this tract afforded ground for the littoral growth of the jungles that formed the coal on its oscillating borders, and in its lagoons, now shut up by bars, and now losing their marsh features by influx of the sea. Succeeding ages still brought oscillations and changes, until the Jurassic seas crept over this old ridge or shoal, and the Cretaceous seas quite buried it, at first in sands and clays, and ultimately by the calcareous ooze of oceanic depths.

But again another contracting crush of the earth's crust operated on the old weak lines, and the buried ridge slowly uprose, and its coatings of thick strata were worn off by sea and rain, making pebbles and sands for the Lower Tertiaries; and, still rising, it was at length laid bare in the Franco-Belgian and the Bristol areas, whilst our Wealden valley of elevation, and those of Kingsclere, Shalbourn, and Pewsey, show where its uneven back approaches near the soil.

After Mr. Godwin-Austen's lecture the geologists listened to Prof. Rupert Jones while he explained the beautiful and complex Weald, and pointed out the many Lower Greensand hills and knolls which fringe the northern edge of the valley, and give to this tract of country its far-famed picturesque beauty.

Prof. Jones clearly showed that the hills and vales coincide with the harder and softer strata, brought up by grand but gentle curves, in orderly arrangement, round a long elliptic dome, reaching from Alton on the west to Hastings and, beyond the Straits, to France, and worn down by natural agencies, of long continuance, from a high broad ridge to the present comparatively low series of lesser ridges.

EXCURSION TO GUILDFORD.—June 25th, 1877.

Director—R. A. C. Godwin-Austen, F.R.S.

(Report by C. J. A. Meÿer, F.G.S.)

(*Proc. Vol.* v. *p.* 161.)

On this occasion members assembled at Chilworth Station. After a few words as to the proposed course of the excursion from the Director they proceeded to examine a bed of Elephant gravel exposed in a new road-cutting. This gravel, which formed an eastern extension of the Peasemarsh valley-gravel, was observed to consist largely of unrolled and broken flints, mingled with fragments of the Bargate stone, Chert, and Carstone (Ironstone), of the Lower Greensand. It contained apparently neither rounded flints nor flint pebbles. The gravel rested here on Hythe beds; further westward it covered both Atherfield Clay and Weald Clay.

The Tillingbourne stream, which was presently crossed on the way towards St. Martha's Hill, was described as running partly on the Weald Clay and partly on the Atherfield Clay, or lowest member of the Surrey Greensand. At the foot of St. Martha's Hill the party separated into two groups—one with Prof. Morris, taking the shortest path to the hill-top; the other, under Mr. Godwin-Austen, taking a longer route, with the chance of finer sections. At the top of St. Martha's, and while waiting for the re-union of the party, Mr. Meÿer described briefly to those present the succession of the strata included in the Surrey Greensand. On mounting the hill they had passed over in succession the outcrop of the Atherfield Clay, Hythe beds, Sandgate beds, and Folkestone beds of the Lower Greensand. The Atherfield Clay (first noticed in England by Godwin-Austen in 1843)* is here very rich in fossils in its lowest beds, which are most unfortunately, however, very rarely exposed. The Hythe beds and Sandgate beds exhibit by comparison a singular dearth of fossils —*Exogyra sinuata*, *Hinnites Leymerii*, *Terebratula sella*, an *Ammonite* or two, and a species of *Belemnite*, probably completing the list of those obtainable in this district. The pebble-bed and Bargate stone series, forming the base of the Folkestone beds, contains a fauna, remarkable chiefly for its wide range, and from its differing so entirely in this district from that of the lower

* Proc. Geol. Soc., vol. iv., pp. 167, 196.

beds. The ferruginous sand, with Carstone capping the hill on which they stood, was wholly unfossiliferous. This sand-bed had here a thickness of about 130 feet. In the Isle of Wight, where it was also unfossiliferous, its thickness was even greater. At Folkestone, curiously enough, it was almost entirely absent; its position being there held by a detrital bed of about one foot in thickness.

Turning now towards Guildford the Warren Farm Section of highly inclined Grey Chalk and Chalk Marl was next visited; specimens of *Nautilus elegans*, *Terebratula obesa*, and *Inoceramus* rewarding the search for fossils. The two Chalk pits in Quarry Street were also briefly visited. The lowest of these contains but few fossils only of the zones of *Inoceramus labiatus*, *Terebratulina gracilis*, and *Holaster planus*. The larger and higher quarry embraces a section displaying the zones of *Holaster planus*, *Micraster cor-bovis*, and *M. Desori* (?); and, in great force, the zone of *Micraster cor-testudinarium*, with many of the associated fossils. Sponges and cone like pressure-striated concretions abound in both quarries on certain limited horizons.

On reaching Guildford the members took carriages for the drive to Seale Rectory, near Farnham, the course taken being along the top of the Hogsback. It was interesting to observe the subtle differences in outline and fertility of the country to north and south of this dividing ridge of Chalk.

EXCURSION TO GUILDFORD AND THE NEW RAILWAY WORKS IN PROGRESS THERE.

SATURDAY, APRIL 26TH, 1884.

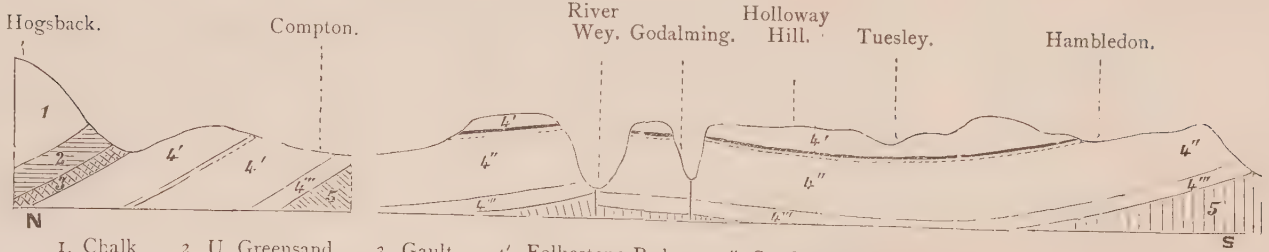
Director—Lieut.-Col. H. H. GODWIN-AUSTEN, F.R.S.

(*Report by* THE DIRECTOR.)

(*Proc. Vol.* viii. *p.* 390.)

STARTING from Chilworth Station the Director first showed the members present the gravel beds close by, which are about 200 feet above the sea. They then proceeded down the valley of the Tillingbourne, and were shown the gravel-beds at East Shalford, where they are about thirty feet above the present stream and below the top level of the Neocomian scarp that bounds the Tillingbourne on its right bank at this part of its course. The party then crossed the ridge of the Lower Greensand forming Chantry Down, descending into the next valley which lies on the

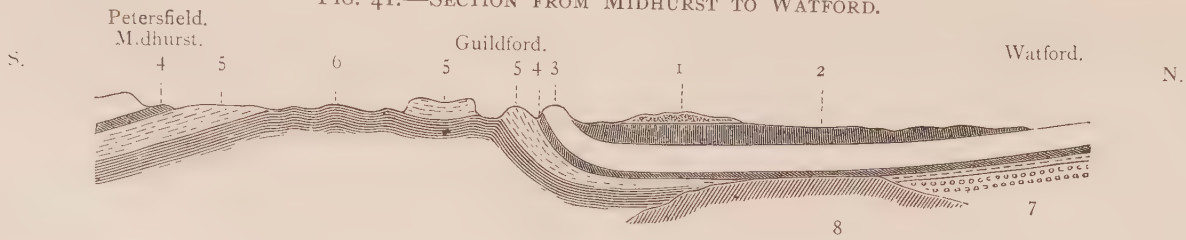
FIG. 40.—SECTION THROUGH GODALMING FROM NORTH TO SOUTH.



1. Chalk. 2. U. Greensand. 3. Gault. 4'. Folkestone Beds. 4''. Sandgate and Hythe Beds. 4'''. Atherfield Beds. 5. Weald Clay.

NOTE.—The "fault" shown in this Section as occurring near Compton is greatly exaggerated, and, though certainly existing at this point, might have been better represented by a sudden bend, or anticlinal.

FIG. 41.—SECTION FROM MIDHURST TO WATFORD.



1. Upper and Middle Eocene. 2. Lower Eocene. 3. Chalk. 4. Middle Cretaceous. 5. Lower Cretaceous. 6. Wealden. 7. Purbeck and Oolite. 8. Older rocks.

outcrop of the Gault ; and, noticing that formation and the Lower Chalk at the old Chalk pits, proceeded to Guildford by Pewley Hill.

The cutting at the London Road was next visited, where the Director pointed out the position of a series of high-level sands and gravels, composed almost entirely of material from the Lower Greensand, having its base sixty feet above the present level of the Wey, and resting on the Woolwich and Reading beds and London Clay, and, east of the railway bridge, on the Chalk. He explained that these deposits are a very much older series than those they had been shown on the Tillingbourne and at Peasemarsh.

The newer Drift-gravels, resting on these sands, were also shown, and the spot where a few land shells had been found was pointed out, attention being directed to the varied character of this Drift, and to its very angular, chalky character as it approaches the solid Chalk.

The party then walked through the cutting eastward, Col. Godwin-Austen showing the spot, at its deepest part, where the mammalian remains were found ; and, passing again over the Eocenes, and seeing the shell-bed between the London Clay and the Woolwich and Reading Series, got into the train of trucks placed at their disposal by Mr. Wills, engineer of the works, and were taken to East Horsley, as far as it was then possible to proceed. There they were able to see the deep cuttings in the London Clay excavated by means of a "steam-navvy." The greater number then, leaving the train, walked over the Downs by Pebble Farm and Farley Heath to Gomshall Station, for their return journey to town.

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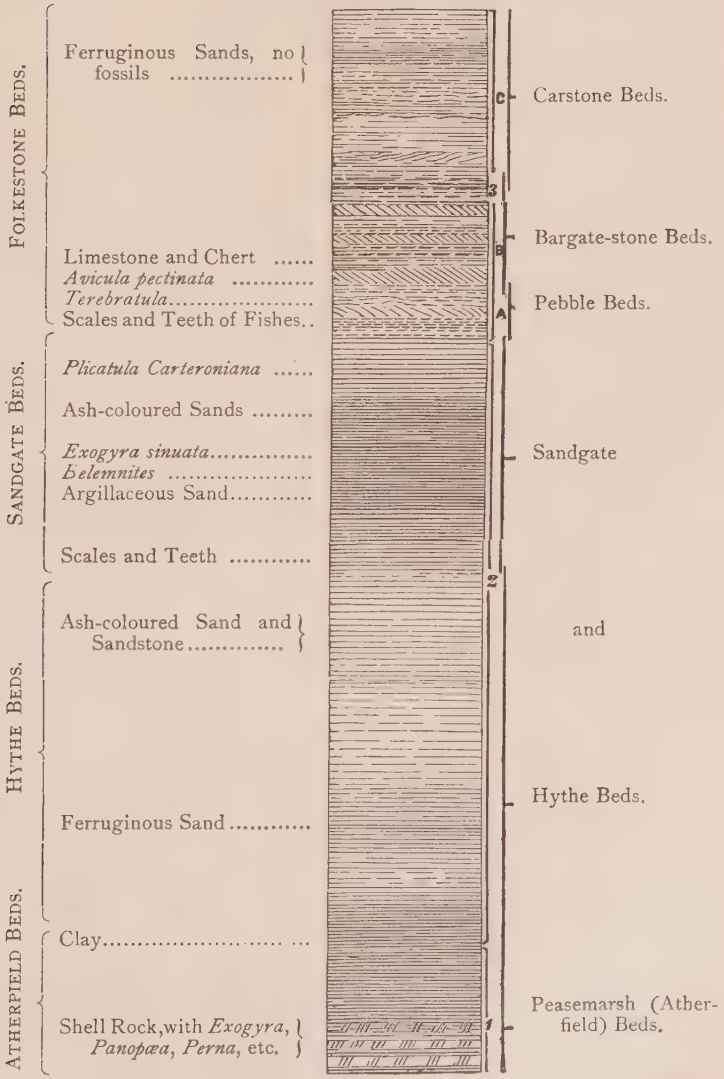
FIG. 42.—VERTICAL SECTION OF THE LOWER GREENSAND AT GODALMING.

Scale—80 feet to 1 inch.



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TILBURSTOW AND NUTFIELD.

[A BRIEF report of an excursion to *Tilburstow* and *Nutfield*, on May 28th, 1870, is given in Proc., vol. ii., p. 35. An account of another on June 13th, 1874, J. Logan Lobley, Director, may be seen in Proc., vol. iv., p. 153. Another visit to the above places, Mr. Lobley again being Director, was made on June 4th, 1877. The same ground was traversed on both these last-named visits, but the report of the latter being much the fuller is alone given here. On June 23rd, 1888, there was an excursion to *Caterham*, *Godstone*, *Tilburstow*, and *Nutfield*, the Director being Prof. G. S. Boulger. A report of it will be found in the Proceedings, vol. x., p. 496.]

EXCURSION TO CATERHAM, GODSTONE, TILBURSTOW, AND NUTFIELD.—MONDAY, JUNE 4TH, 1877.

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by* THE DIRECTOR.)

(*Proc. Vol.* v. *p.* 155.)

BEFORE arriving at Caterham the party were much interested by seeing the Bourne flowing along the bottom of the usually streamless Kenley Valley. This intermittent river flows only after unusually wet seasons, the Chalk of the district absorbing ordinary rainfalls. In recent years there had been flows in 1866, 1873, and a small flow in 1876. This year (1877) the flow is large, and is the subject of much comment and speculation amongst the residents of the locality, some of whom even now ascribe the appearance of the river to a mysterious or supernatural agency, although in 1660 the true cause was known. Childrey, in the *Britannia Baconica* of that year, says :—"The

rising of a Bourn or stream near Croydon (as the common people hold) presageth death or the plague; and it hath been observed to fall out so. The rising of Bourns in places where they run not always, we have before proved to be caused by great wet years, which (according to Hippocrates' observation) are generally the most sickly; and if they prove hot as well as wet (because heat and moisture are the greater disposers to putrefaction) they prove also malignant and for the most part pestilential. And the reason why the using [? rising] of this Bourn doth not always presage the plague, is because all wet years do not presage hot." *

Mr. Baldwin Latham, in a letter to the *Croydon Chronicle*, dated January 25th, 1877, gives the following particulars of the flow of the present year:—"The flow of the Bourn from Marden Park and that at Riddlesdown joined each other on Monday, the 22nd inst., and now form one continuous stream, and the flow is making rapid progress towards Croydon, having this day (Thursday) reached to a point north of Caterham Junction. The Bourn now makes its appearance at the highest point a short distance below Bughill Farm, and from this point to a considerable distance below the Rose and Crown Inn, under Riddlesdown, the water continuously receives considerable accessions to its bulk. The volumes of water flowing from Marden Park, at Wapses Lodge, have been as follows:—

"On the	19th,	at the rate of	1,516,000	gallons	in 24 hours.
,,	20th	,, ,,	2,567,000	,,	,,
,,	23rd	,, ,,	4,421,000	,,	,,
,,	24th	,, ,,	4,623,000	,,	,,

"At this latter date the water below the Rose and Crown was flowing at the rate of 10,584,000 gallons in twenty-four hours, while at Warlingham Station, a point intermediate between Wapses Lodge and the Rose and Crown, the volume flowing was at the rate of 6,855,000 gallons in twenty-four hours. From my last letter it will be seen that the volume of water flowing out of the Bourn Culver, at Croydon, on the 15th inst., was at the rate of 9,300,000 gallons in twenty-four hours. On the 21st it was at the rate of 8,837,000 gallons in twenty-four hours; and on the 24th inst. at the rate of 8,761,000 gallons in twenty-four hours. The falling-off of the quantity is no doubt due to local effects arising from the diminution of the rainfall."

* *See* W. Whitaker, Geol. London Basin (Geol. Surv.), 1872, p. 391.

On alighting from the train at Caterham the members found a collection of the fossils of the Chalk of the neighbourhood had been brought by Mr. Cluse, of Caterham Junction, not only for inspection, but also for distribution. At a short distance from Caterham Station, on the road to Godstone, a visit was paid to a quarry in the Lower Chalk, and here the Director explained that from Caterham Junction to Caterham, lower and lower beds of the Chalk had been traversed, the section at the Junction showing Mr. Caleb Evans' Upper Kenley, or Riddlesdown, Beds of the Upper Chalk, while this quarry was in the Lower Marden Park Beds of the Lower Chalk. These beds are characterised by *Belemnites plenus* and *Holaster subglobosus*.

Rain arrested progress for a little time, but on its cessation the party made their way to the great Firestone Quarries in the Upper Greensand, on the Godstone road, which have been worked underground for a long period, though they are not so ancient as others a little distance to the west, from which stone for Windsor Castle was obtained in the time of Edward III. Although at the ends of the workings there are places in which a considerable quantity of water lies, the galleries, along which trams are laid, are comparatively dry. The Firestone is quarried from a calcareo-siliceous bed of the Upper Greensand, which has an extension not limited to Surrey. Curiously enough, however, near to the opening to the quarries another excavation had been made, but no Firestone had been met with. At this place some fossil sponges *(Siphonia)* were found. Under the guidance of the manager of the Quarries a visit was paid to a quarry near Marden Park, in which a harder stone, used for hearthstones, occurs. Proceeding southwards, an exposure of the Gault was found in a field to the east of the Godstone road, and a few fragments of the characteristic *Belemnitella minima* were extracted from the clay. After passing a pit in which a fine white sand is worked, an exposure of Lower Greensand, the pretty village of Godstone was reached.

After luncheon the road to Tilburstow Hill was taken, and a "head-water" of the Medway, Broad Mead Water, having been crossed, the ascent of the commanding elevation of Tilburstow commenced. A deeply-cut, disused lane, almost covered by tangled vegetation, opens on to the hill-side, and here the party paused and, turning to the north, surveyed the beautiful valley they had just crossed, lying between Tilburstow Hill on which they stood and the Chalk Hills of the North Downs. The bare

but green Chalk hills on the opposite side of the valley, diversified with white patches where excavations occur along their sides, contrasted with the darker green and well-wooded lower ground of the Upper Greensand and Gault. The Lower Chalk of Caterham had given place to the Upper Greensand of the Firestone Quarries, and this had been succeeded by the Gault of the bottom of the valley and the Lower Greensand, of which the whole of Tilburstow Hill was composed, and the commencement of which had been seen at the Godstone sand-pit. Thus a regular and continued sequence of beds had been traversed from Caterham Junction to the spot on which they stood.

Continuing the ascent, the party soon reached the summit of the road, where a fine section of the ferruginous sands of which the Lower Greensand so largely consists is exposed. The tendency of the oxide of iron to separate from the sand and form "boxes" is well exemplified at this place, and some good specimens of these structures were obtained. The top of the hill is much higher than the summit of the road, and is only gained by a very steep and difficult path; but the difficulty was soon overcome, and the members stood on the little plateau under the trees which crown the summit of Tilburstow, and were struck with the extent and extreme beauty of the landscape which met their eyes, for, stretching to the east, to the west, and to the south, as far as the eye could see, lay before them the great Wealden district. With the aid of the Geological Survey Maps of the Wealden Area, the Director described its physical features, and explained the theories held to account for the denudation of the great mass of Cretaceous strata which had been removed. Mr. Boulger having said a few words on the plants of the neighbourhood, the party left the hill-top, and after visiting some Kentish Rag quarries in the Lower Greensand, made their way westward along the hill, through the villages of Bletchingley and Nutfield, to the well-known Fuller's Earth pits, also in the Lower Greensand. The argillaceous earth here worked is finer than that of *the* Fuller's Earth (Jurassic), and is largely used in the arts. Masses of barytes occur in these pits, and, when broken up, show fine brown crystals, sometimes having small cubical crystals of iron-pyrites attached. Nearly every member of the party succeeded in carrying away a good specimen.

A further walk of about a mile brought the party to Redhill.

Mr. C. J. A. Meÿer, F.G.S., kindly furnished the following list of fossils obtained from the Nutfield Lower Greensand:—

Nautilus undulatus (Sow.)
Ammonites Nutfieldensis (Sow.)
„ *consobrina* (D'Orb.)
„ sp.
Pleurotomaria Anstedi (Forbes).
Natica sp.
Venus Vectensis (Forbes).
Trigonia ornata (D'Orb.)
„ *Archiaciana* (D'Orb.) (?)
„ *Vectiana* (Lycet).
Nucula, two or three species.
Pholadomya Raulniana (D'Orb.)
Panopæa nana (Coquand).
Panopæa Prevostii (D'Orb.)
Mytilus
Lima Cottaldina (D'Orb.)
Inoceramus sp.
Plicatula Carteroniana (D'Orb.)
Pecten, allied to *P. Milleri* (Sow.)
„ near to.
Janira Morrisii (Pictet).
Exogyra Tombeckiana (D'Orb.)
Hemipneustis Fittoni (Forbes), common.
Cone of *Pinites*.
Fragments of Wood—abundant.

[On July 13th, 1880, there was an excursion to *Limpsfield* (Surrey), the Directors being Prof. Prestwich and W. Topley. Gravels yielding palæolithic implements were inspected. See in connection with this excursion, that to *Ightham* (Kent), June 1st, 1889.]

EXCURSION TO THE NORTH DOWNS, SURREY.

Monday, 6th May, 1878.

Directors—Prof. J. Morris, F.G.S., and W. Whitaker, F.R.S.

(*Report by* W. Whitaker).

(*Proc. Vol.* v. *p.* 495.)

The party went by train to Caterham, and then walked southwards to the hill on which the Waterworks stand. The outlier of Oldhaven Beds here was examined, and it was shown how the wash of pebbles from this formation down the hill side, or still more down the gentle northerly slope, obscured the junction with the Chalk, and might easily lead an observer to draw the boundary-line of the Oldhaven Beds too low.

Attention was drawn to the section given by the deep well at the Waterworks, the shaft of which passed through a great thickness of Oldhaven Beds (nearly 90 feet on one side, and 140 on the other); the Chalk was then pierced to the depth of about 455 feet; Upper Greensand, about 55 feet, succeeded, and then Gault, which reached the hitherto unrecorded thickness of over 340 feet: sand (Neocomian) being found below, and the total depth reaching 874 feet.

A large pit just south of the Waterworks showed the nature of the Oldhaven Beds—a deposit of flint pebbles in a sandy matrix, the pebbles all perfectly rolled; but in places, at the bottom,

FIG. 43.—CAVITY IN THE CATERHAM GRAVEL PITS.
Scale—10 feet to 1 inch.

there was seen an irregular mass of angular flints in a loamy matrix; this, it was suggested, might be due to the dissolving away of the Chalk by carbonated water, leaving the insoluble flints behind, which is all the more likely from the fact that the Old

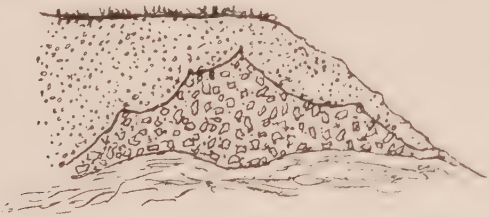

FIG. 44.—LOAM-WITH-FLINTS IN THE PEBBLE-BEDS AT CATERHAM.
Scale—10 feet to 1 inch.

haven Beds must fill a deep pipe at the Waterworks (as shown by the well-section), and such pipes are produced by the dissolution of chalk below Tertiary and Drift beds [a detailed description of these Gravel Pits, by T. V. Holmes, may be seen in Proc., vol. ix. 1885, p. 105, from which the illustrations are taken.]

An advance having been made to the end of the Chalk escarpment, Prof. Morris gave an address on the connection of the scenery of the district with the geology. Each successive formation (Chalk, Upper Greensand, Gault, Lower Greensand and Weald Clay), was shown to have its own peculiar effect on the

surface, the contours of which moreover are greatly affected by the regular northerly dip of the beds.

The Chalk ridge having been descended, two trenches, dug at the foot of "White Hill," by Mr. Gilford, for the benefit of the Members, was examined. The more westerly and higher of these showed the junction of the Chalk and the Upper Greensand, or rather the passage between them; for the Chalk Marl was seen to be somewhat sandy at its base, and to put on the glauconitic character of the "Cambridge Greensand" (which has been shown to be the bottom-bed of the Chalk Marl), until at last it passes into the clayey greensand that in this district forms the top division of the Upper Greensand.

The second trench showed a passage from the Upper Greensand into the Gault; the lower part of the former, consisting of more or less calcareous sandstone and sand, becoming more clayey towards the base, and merging into the top part of the Gault, which is sandy, somewhat calcareous, and light-coloured.

After lunching with Mr. Gilford, a start was made westward, along the terrace of the Upper Greensand.

Some small sections, showing the nature of the formation, the dip, etc., were noticed, and it was pointed out how the northerly dip, of about 5°, resulted in making the outcrop less winding, that is, less affected by undulations of the ground, than would be the case with more horizontal beds. The lines dividing the Upper Greensand from the Chalk above and from the Gault below were approximately traced (on the "six-inch" Ordnance Map), and it was shown how this could be done from evidence given by the shape of the ground, the character of vegetation, and the occurrence of springs, in the absence of sections.

After a time the party came unexpectedly on a new and hitherto unrecorded section, which alone was worth a visit. It was a road-cutting on the west of Mr. Frith's new house, and continuous from the base of the Chalk Marl to the top of the Gault. The beds shown were as follows, and the section confirmed the conclusions drawn from Mr. Gilford's trenches:

CHALK MARL, full of green grains at the base, and passing down into the next bed.

UPPER GREENSAND.	Green sand, partly calcareous.
	Green and greenish-grey sand, with layers of sandstone; the stone more frequent lower down.
	Sand, partly calcareous, with layers of stone; lower down more clayey, and the stone-layers lost; passing down into the next.

Light-coloured sandy clay. Upper part of GAULT.

The walk was continued along the Upper Greensand, the outcrop of which was found to be rather narrower than is shown on the Geological Survey Map (made many years ago, and without the evidence above described). Before reaching Merstham a casual look was given to the large chalk-pit east of the railway, and then the party divided, some returning to London, others walking southward to Redhill, across the outcrop of the Gault to that of the Lower Greensand. The larger number left took train to London, but a band of six continued their southerly stroll up the dip slope of the Lower Greensand to a Fuller's-earth pit close to the top of the escarpment of that formation, and were well rewarded by the sight of a fine section, the beds shown being as below, and all probably belonging to the Sandgate Beds of the Geological Survey :—

Brownish clay, in places with broken-up stone at top.
Sandstone, the upper part rubbly, and sometimes soft, the lower part more massive.
Fuller's earth, ironstained at top, the rest bluish-grey.

[On June 14th, 1884, J. Logan Lobley was Director of an excursion to *Caterham* and *Merstham*, the district traversed being the same as that described in the "*Excursion to the North Downs, Surrey.*" It is reported in Proc., vol. viii. p. 411. Besides seeing various sections of Oldhaven Beds, Chalk, and Upper Greensand, the party also inspected the site of an ancient British camp at Warr Coppice.]

References.

Maps.—Ordnance Survey. Geological. Sheets 6 and 8. 8*s.* 6*d.* each.
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Books.—W. Topley, Geology of the Weald, 8vo, *London* (Geol. Surv.) 1875. 28*s.*
W. Whitaker, Geology of the London Basin, 8vo, *London* (Geol. Surv.) 1872. 13*s.*

REDHILL, NUTFIELD AND CRAWLEY.

[The first excursion to the above district took place on April 9th, 1861 (Proc., vol. i. p. 149). The second in 1868, during the cessation of any issue of Proceedings. A report of the third—to *Redhill* and *Nutfield*—is given below :—]

EXCURSION TO REDHILL.—Saturday, 26th June, 1880.

Director—C. J. A. Meÿer, F.G.S.

(*Report by* The Director).

(*Proc. Vol.* vi. *p.* 373).

The Fuller's-earth beds in the Lower Greensand in the vicinity of Redhill and Nutfield formed the principal point of interest in this excursion. The strata yielding Fuller's-earth in workable quantity occupy the northern slope of the sand-ridge between Redhill and Bletchingley. The position in the Cretaceous series of these particular Fuller's-earth beds has been long a matter of uncertainty amongst geologists, some observers placing them in the Hythe Beds, others in the Sandgate Beds of the Lower Greensand. It was on this occasion pointed out and explained to the members present that the Fuller's-earth Beds of Nutfield really belonged to, and represented in position, a part of the Folkestone Beds of the Lower Greensand. It was explained that the typical Folkestone Beds, as existing at Folkestone and between Folkestone and Sandgate, consisted throughout their whole thickness of alternations of stone, sand, and sandy clay. These Folkestone Beds proper *westward* of Folkestone took on, however, in their upper part, a constantly increasing thickness of pure sand beds. These sand beds, which consisted of white and iron-stained sand, with "carstone" and occasional thin partings of Fuller's-earth, had a thickness near Maidstone of about 30 feet. Near Reigate their thickness was about 90 feet. Further westward, near Guildford, their thickness was not less than 130 feet. At Shanklin, in the Isle of Wight, their thickness probably exceeded 200 feet. Unlike the typical Folkestone Beds, these overlying sand beds were unfossiliferous. Wanting at Folkestone, they were, westward of that place, interposed between the Gault and the Folkestone Beds proper. The Fuller's-earth and accompanying stone beds occupying the northern slope and crest of the sand-ridge between Redhill and Bletchingley were thus shown to represent the true Folkestone Beds, and it was pointed out that representatives of the Sandgate Beds and Hythe Beds of the Lower Greensand occupied the southern escarpment only of the same sand-ridge.

[On May 21st, 1887, there was an excursion to *Merstham*, *Redhill*, and *Reigate*, W. Topley, F.R.S., Director, of which there is a full report in Proc., vol. x. p. 154.]

EXCURSION TO REDHILL AND CRAWLEY (NORTHERN VALLEY OF THE WEALD).—Saturday, May 6th, 1882.*

Director—J. Logan Lobley, F.G.S.

(*Report by* The Director).

(*Proc. Vol.* vii. *p.* 369).

On arriving at Redhill Junction Station the party made their way to Redhill Common, on the summit of a hill that rises boldly on the south of the town to an elevation of 475 feet above the sea-level, and affords a complete view of the district to be observed. The central elevated region (the Forest District), extending east and west, rises from a low plain, lying along its northern side, while a similar vale skirts it on the south, both these vales being overlooked on the north and south respectively by elevations which form the bounding escarpments of the Wealden area. The central elevated district consists of the Hastings Sands, the parallel vales to the north and south of the Weald Clay, and the bounding escarpments of the entire area of the Lower Greensand and the Chalk, the latter forming the North and South Downs. Although the ranges of the Chalk Downs are of about equal general elevation, the Lower Greensand on the south forms features insignificant compared to those of that formation on the north, which become in many places bold hills, and in one case, that of Leith Hill, surpass even the Downs in altitude.

Redhill Common is on the Lower Greensand escarpment, and from its commanding elevation, looking northwards, the parallel Chalk escarpment of the North Downs is well seen for a long distance running east and west, the nearest point being about a mile and a-half distant across the beautiful intermediate Cretaceous valley. Here the Lower Greensand escarpment is cut across by a deep valley, through which the London and Brighton high-road and railway run. This gorge is in line with a fault crossing the longitudinal valley, and extending to the Chalk escarpment at the Merstham tunnel.

Turning to the south, the view from Redhill Common extends

* The next five reports, a second series of excursions to the Wealden area, describe the geology of the country between Redhill and Brighton. (*See* also pp. 35-44.)

over the whole Weald-Clay vale to the central elevations. The South Downs and Chanctonbury Ring are distinctly seen, and thus the entire breadth of the Wealden area from the North to the South Downs is visible. The highest part of the common consists of the Folkestone Beds of the Lower Greensand, which have the usual dip to the north, and pass under the Gault in the valley, but on the face of the escarpment the underlying Sandgate Beds, the Hythe Beds, and lower still, the Atherfield Clay, occur in regular sequence. A very fine exposure of the Folkestone Beds is seen in the large sand pits on the eastern side of the hill, where these beds consist of brightly coloured sands, chiefly of a beautiful deep pink, ranging to crimson. At about half a mile to the east, at the base of the escarpment, the party visited a section of Atherfield Clay, worked here for bricks, in conjunction with Weald Clay from the adjacent Earlswood Common, the commencement of the northern Weald plain. This common was now traversed, the wet and boggy ground bearing witness of the changed character of the underlying strata. It was pointed out that the slight ridges noticeable on this common were due to thin bands of limestone, which occur in the Weald Clay. The limestone, where seen, is partly decomposed, but gives evidence of its fresh-water origin by yielding *Paludina*. Topley ("Geology of the Weald," p. 102) gives the following particulars of the subordinate beds of limestone and sand found at different horizons in the Weald Clay, the maximum thickness of which near Leith Hill is estimated at from 900 to 1,000 feet:—

7 Sand.
6 Limestone, "Sussex Marble" (large *Paludina*).
5 Sand and Sandstone, with Calcareous Grit.
4 Limestone (large *Paludina*).
3 Limestone (small *Paludina*).
2 Sand and Sandstone.
1 Horsham Stone.

Of these, the lowest, the Horsham Stone, is the most important.

The old coach road to Brighton was now gained, and followed for the remainder of the journey to Crawley. Another of the limestone-based ridges was crossed south of Earlswood and Petridge Common, and still another at Horley Lodge, the latter forming the water-shed between two branches of the Mole. After these elevations are passed the Weald Clay forms a plain. This flat

FIG. 45.—SECTION OF THE NORTHERN VALLEY OF THE WEALD. (ABOUT 9 MILES.)

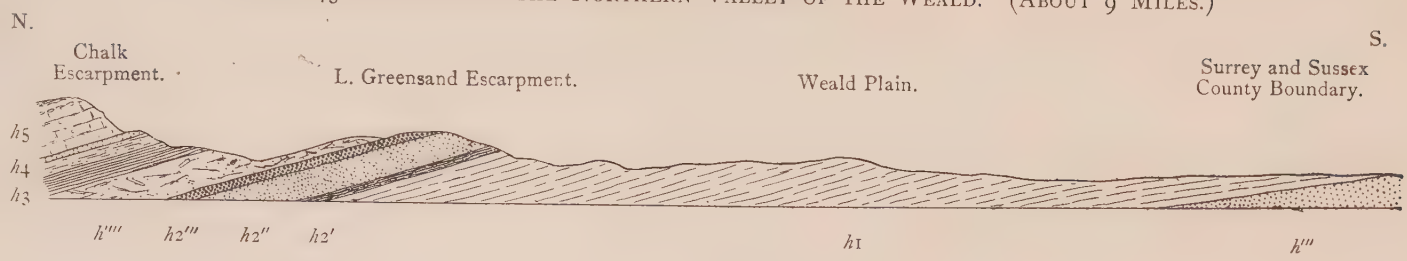
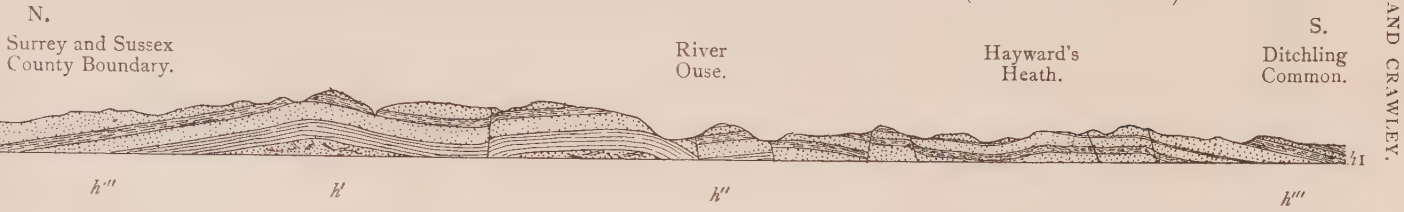


FIG. 46.—SECTION OF THE CENTRAL ELEVATION OF THE WEALD. (ABOUT 12 MILES.)



EXPLANATION OF SIGNS.—*h'* Ashdown Sands. *h''* Wadhurst Clay. *h'''* Tunbridge-Wells Sand. *h1* Weald Clay. *h2'* Atherfield Clay. *h2''* Hythe Beds. *h2'''* Sandgate Beds. *h2''''* Folkestone Beds. *h3* Gault. *h4* Upper Greensand. *h5* Chalk.

country, destitute of sections, though well wooded and cultivated, became somewhat wearisome, but nevertheless nearly the whole party continued to walk through Horley to the little old town of Crawley, passing over, on the way, the county-boundary between Surrey and Sussex.*

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Books.—W. Topley, Geology of the Weald, 8vo, *London* (Geol. Surv.). 1875. 28*s.*

Dixon, F., Geology of Sussex. 1850; and ed. 2, 1878.

See also "Weald Series of Excursions, pp. 35-44.

SUSSEX.

[The last excursion, from *Redhill* in *Surrey*, on the Lower Greensand, to *Crawley* in *Sussex*, ended at the southern edge of the Weald Clay; this begins on the northern edge of the Hastings Sands Series in the immediate neighbourhood of *Crawley*.]

EXCURSION TO WORTH.—June 30th, 1883.

Director—W. Topley, F.R.S.

(*Report by* the Director.)

(*Proc. Vol.* viii. *p.* 185.)

The party assembled at Three Bridges Station early in the afternoon, and walked to Worth Church, passing over the higher beds of the Tunbridge Wells Sand, sections of which are seen in the railway cuttings north of Worth.

Some time was spent in examining the church, an especially interesting example of Saxon architecture, the original ground plan being strictly preserved. The chief architectural peculiarity is in the external upright bands or pilasters of masonry, supporting

* Sheet 76 of the Horizontal Sections of the Geological Survey crosses the Weald District from near Brighton to the North Downs near Merstham, Surrey; its line of direction being almost identical with that of this series of Weald excursions.

another band, which runs as a string-course around the church. The "long and short work," so characteristic of Saxon churches, is well seen here. The stone employed is the Wealden sandstone of the neighbourhood.

A walk through Worth Forest brought the party to the summit of Balcombe Down. The forest is partly of modern planting, replacing the trees cut down for the old ironworks; but there are large tracts of the remains of the ancient forest, chiefly of oak and birch. The site of one of the old furnaces was visited at Cinderbanks, where large heaps of slag are seen, but no remains of the furnaces have been preserved. A large pond formerly existed here, to supply water-power to the ironworks; the dam being partly constructed of slag. Large quantities of cannon were cast at these furnaces, some as late as the latter part of the last century.

From the summit of Balcombe Down an extensive view is obtained over the Weald. The North and South Downs are clearly seen, whilst to the north-west the higher lands of the Leith Hill range (Lower Greensand) bound the view.

A MS. section, made in 1806-7 by John Farey, was exhibited, by which the denudation of the Weald was clearly established. The term denudation, in fact, was introduced by Farey with reference to this district.

Mr. J. W. Hulke, F.R.S., then gave an interesting address on the general characters of the *Dinosauria*, whose remains are found in the Wealden beds, pointing out especially the advances then made in our knowledge of these forms. It was shown that their skeletal characters combined features which in existing reptiles marked different and distinct orders, so that they were generalized types. Their close avian resemblances, hinting at a common ancestry of reptiles and birds, were also touched upon; and allusion was made to the first discovery of the Iguanodon, by Mantell, in the neighbouring Cuckfield Quarry.

From Balcombe Down the party descended to the village of Balcombe, where tea was provided at the Railway Inn.

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EXCURSION TO TILGATE FOREST, CUCKFIELD, AND HAYWARD'S HEATH.

(CENTRAL ELEVATIONS OF THE WEALD.)

SATURDAY, MAY 20TH, 1882.

Director—J. LOGAN LOBLEY, F.G.S.

(*Report by* THE DIRECTOR.)

(*Proc. Vol.* vii. *p.* 372.)

THREE BRIDGES Station, at which the members assembled, is a well-situated point of departure from which to cross the central elevations of the Weald between London and Brighton, the junction of the Weald Clay and the Hastings Sands crossing the railway at this place. Immediately the Weald Clay is left behind dense woods are entered, and these, with the rising sandy ground, leave no room for doubt that the Forest District has been reached. The coincidence of the boundary between the Weald Clay and the Hastings Sands with that between the flat cultivated fields and the wooded rising ground is very remarkable.

A walk of a mile brought the party to a quarry by the side of the railway, affording a good exposure of the uppermost beds of the Hastings Sands, the subdivisions of which were described. They are briefly as follows :—

Subdivisions.

Upper Tunbridge-Wells Sands (with Tilgate Grit), in two parts separated by Cuckfield Clay (local, 15 feet)	100 to 200 feet
Grinstead Clay	10 to 80 feet
Lower Tunbridge-Wells Sands	50 to 100 feet
Wadhurst Clay (with Clay Ironstone)	120 to 150 feet
Ashdown Sands	150 to 500 feet
Fairlight Clays (local, 360 feet)	

The Upper Tunbridge-Wells Sands, as seen in the Tilgate district, are very variable, containing, in some places, as at this quarry, beds of good, though not very hard, building-stone, bands of clays, and pockets of hard nodular calcareous blocks with ferruginous coatings. At other places they are simply compacted sands, sometimes beautifully white glass-sands, with thin shelly sandstones, and at others, as Cuckfield, they contain the

hard calcareo-siliceous stone known as Tilgate Grit, with argillaceous beds, Cuckfield Clay.

Leaving this quarry higher ground was traversed, and a picturesque route through the forest led to Cinderbanks, where the path descends and crosses the railway to a secluded hollow, in which one of the head waters of the Mole meanders over Grinstead Clay, which has a maximum thickness of about fifty feet in the neighbourhood of East Grinstead. This Clay has a general resemblance to the Wadhurst Clay, below the Lower Tunbridge-Wells Sands, but does not appear to contain so much ironstone. As the land rises rapidly, the Lower Tunbridge-Wells Sands are not seen, and the Clay occupies but a very narrow area where the stream has cut through the Sands.

Hence the party made their way to Balcombe Down, 471 feet above sea-level, and a commanding position on the great spoil-heap over Balcombe tunnel (the summit of the London and Brighton Railway) was taken up. The Director explained that the principal anticlinal axis of the Weald had now been reached, the same axis as that visited by the Association in July, 1879 (see Proc., vol. vi.). Topley has clearly shown by the map at the end of the "Geology of the Weald" that there are several anticlinals in the Wealden area having a general parallelism, but that one passing through Crowborough Beacon, Ashdown Forest, Balcombe Down, St. Leonards Forest, and so on to Horsham appears to be the chief, passing, as it does, through the central highlands, and being coincident, at a little east of Balcombe Down, with the water-parting of three hydrographical areas, those of the Medway, the Mole, and the Ouse. An extensive and varied view over a large portion of the Forest District of the Weald rewarded the geologists.

All now proceeded westwards along the anticlinal by a high level road coincident with the water-shed of the Ouse and the Mole. From Handcross the London and Brighton high road was followed. This road, running southwards, descends by Staplefield Green to the Ouse Valley, at the bottom of which, and rising on the south side to some elevation, occurs a remarkable outlier of Weald Clay running east and west for about six miles. This is caused by the folding of the strata, which dip from the anticlinal at Handcross, and present the Weald Clay along a synclinal at a lower level than the Tunbridge-Wells Sands, which are, however, lifted up again on the south by a fault.

The strata to the south are much faulted, and the Tunbridge-

Wells Sands, the Grinstead Clay, and patches of Weald Clay form the ground in a most irregular manner. Near the summit of the southern side of the valley the Tunbridge-Wells Sands afford a fine white glass-sand without any cementing material, though at a few yards distance a shelly sandstone is visible.

Some distance further, at a higher level, at Whiteman's Green, near Cuckfield, the famous "Iguanodon Quarry" of Mantell is reached, where the Tilgate Grit, with a conglomerate, is covered with a patch of Weald Clay. The Iguanodon tooth, discovered here in 1822 by Mrs. Mantell, led to the determination of this animal, whose bones had been observed some years previously by William Smith. Fragments of bone of this dinosaur are frequently found in the quarry. The town of Cuckfield was next passed through, and the party assembled in the park overlooking the Southern Weald Vale, commanding a fine view of the range of the South Downs, with Ditchling Beacon, the Devil's Dyke, and Chanctonbury Ring. Returning to Cuckfield, a further walk to Hayward's Heath Station, over very remarkable ripple-marked Wealden flagstones, terminated the day's proceedings.

[An excursion confined to the Hastings Sands district of *East Grinstead* and *West Hoathly* took place on June 27th, 1885, and is reported in Proc., vol. ix. p. 217. In that described below the southern boundary of the Weald district was reached.]

EXCURSION TO HAYWARD'S HEATH AND DITCHLING BEACON.—Saturday, June 10th, 1882.

Director—J. Logan Lobley, F.G.S.

(*Report by* the Director.)

(*Proc Vol.* vii. *p.* 395.)

The third of this Weald series of Excursions between London and Brighton was devoted to the district between Hayward's Heath and Ditchling Beacon (the summit of the eastern section of the South Downs) comprising a southern Weald Clay Vale.

The ground crossed is, therefore, geologically similar to that traversed between Redhill and Three Bridges in May, (see p. 116), but with the difference that we get upon higher, not lower beds as we go southward. One of the minor Wealden anticlinals occurs at Hayward's Heath, where brickyard-sections show Cuckfield Clay at the surface; the ground is then formed of Tunbridge-Wells Sands nearly to Wivelsfield, where a depression on Weald

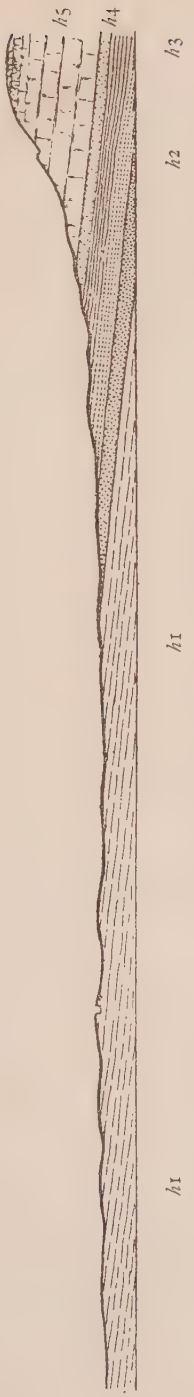

FIG. 47.—SECTION OF THE SOUTHERN VALLEY OF THE WEALD. (LENGTH OF SECTION ABOUT 4 MILES.)

N.B.—Vertical Scale greatly exaggerated.

EXPLANATION OF SIGNS.—*h*1 Weald Clay. *h*2 Lower Greensand. *h*3 Gault. *h*4 Upper Greensand. *h*5 Chalk.

Clay is met with. This is, however, very narrow, and Wivelsfield itself stands on what is almost an inlier of Hastings Beds. This is soon crossed, and then the Weald Clay vale is reached. Ditchling Common is a very extensive tract, entirely on the Clay, which here forms ground more or less undulating, the highest part having a considerable elevation. A divergence was made so as to enable the party to visit the very extensive brickyards near Keymer Junction. The section of the Weald Clay here is one of the best in the entire Wealden area, being some fifty feet deep. The Clay at this place is used solely for brick-making, the terra cotta being made at Ditchling Pottery, about a mile distant, from a finer clay. To this pottery the party proceeded, and the interesting process of terra cotta manufacture was explained to them by the manager. After seeing the Clay the southern part of the common was crossed, and as the village of Ditchling was approached the changed character of the ground indicated the presence of the Lower Greensand, and at the village itself a section of the Folkestone Beds was found behind the hotel, and the ancient church stands on a small hill of these Beds. There does not appear to be any representative of the Atherfield Clay in this neighbourhood, but the Hythe Beds,

the Sandgate Beds, and the Folkestone Beds are present, though forming features comparatively insignificant when compared with those which fringe the North Downs. The outcrop of the Gault, too, is narrow, and is indicated by the dark colour of the ploughed land above it, locally called "Blackland." The Upper Greensand also is crossed at the base of the hills, and the Grey Chalk is shown by fine sections at a little elevation. Continuing the ascent the higher beds of the Chalk are successively passed over until the summit of the Downs is reached, consisting of a bed of the Upper Chalk with flints. Ditchling Beacon is 814 feet above the sea-level, and, as it is the highest point in the Sussex Downs, affords a magnificent view on all sides. The southern part of the Weald crossed during the day was looked over on the north, while to the south the view extended across the Downs and far out to sea. A route due west along the summit of the Downs was next taken, and a descent made near Combe Down, when a visit was paid to the new waterworks, where a deep well had been sunk through the Lower Chalk. Passing through Keymer village, at which a section of the Folkestone Beds was seen, the party hastened to Hassock's Gate station for the return journey to London.

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See also "Weald Series of Excursions," pp. 35-44.

EXCURSIONS TO BRIGHTON.

[*Brighton* was first visited in 1866 while the issue of Proceedings was suspended. The next excursion there took place in 1873, the Directors being Dr. Henry Woodward, F.R.S., and Prof. T. Rupert Jones. A brief report of it is given Proc., vol. iii. p. 239. On arrival at Brighton the party first visited the Devil's

FIG. 48.—DIAGRAM SECTION ACROSS THE SOUTH DOWNS, NEAR ARUNDEL, SHOWING OLD SEA CLIFF AND ESCARPMENT.

Dyke, and there the various theories advanced to account for the denudation of the Weald were discussed by the Directors. Returning to Brighton by way of the Western Valley and past Furze Hill, the area of the Tertiary deposits, the party alighted at Kemp Town to observe the "Elephant Bed," which was especially well seen in consequence of a recent fall of a portion of the cliff. After luncheon the Museum and Aquarium were visited. *Brighton*, *Newhaven* and *Seaford* were the scene of an excursion on Easter Monday and Tuesday (April 11th and 12th) 1887; Henry Willett and W. Topley, F.R.S., being Directors. An account of this excursion appears in Proc., vol. x. p. 141. Many of the members who were present at *Brighton* in 1887 had slept at *Bognor* on the two previous nights, and while there had visited *Pagham* Church and *Selsea Bill* under the guidance of W. Whitaker, F.R.S. On July 12th, 1890, there was an excursion to *Arundel*, the Director being Clement Reid.]

EXCURSIONS TO LEWES.

[THE first visit took place on August 6th, 1862; a report may be seen in Proc., vol. i. pp. 274-7. The party conducted by Captain Noble, of Mansfield, visited Lewes Castle, after which

they proceeded to the Chalk quarries at *Southerham*, and later ascended *Mount Caburn*, descending again into Lewes by way of the "Dumb." The writer of the report remarks that numerous sinkings have shown the alluvial deposits of *Lewes Level* to consist of:—

1. Bog-earth and peat, with leaves of hazel, oak, and birch, enclosing large trunks of trees. This bed is almost 5 ft. thick.

2. Blue clay, with fresh-water shells of the same species as those now inhabiting the Ouse and neighbouring ditches, and the *tubifex* of caddis-worms. Bones of horses and deer have been found at the bottom.

3. Clay containing fresh-water shells.

4. Blue clay enclosing marine shells. The skull of a narwhal, and one of a porpoise, have been obtained from this deposit. These last three beds combined vary from three to thirty feet in thickness. Finally, there is a bed of pipe-clay, evidently derived from the subjacent chalk.

Another excursion to Lewes was made on April 22nd, 1867, during the cessation of the issue of Proceedings.]

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EXCURSION TO EASTBOURNE AND ST. LEONARDS.

MAY 23RD AND 24TH, 1873.

Directors—The Rev. E. S. DEWICK, M.A., F.G.S., JOHN HOPKINSON, F.G.S., and J. E. H. PEYTON, F.G.S.

(*Report by* JOHN HOPKINSON.)

(*Proc. Vol.* iii. *p.* 211.)

On arrival, the members at once proceeded to Eastbourne College to inspect the local fossils in the College Museum. This

collection was formed by Mr. Dewick, who pointed out some of the more remarkable specimens, and gave a brief account of the succession of the beds in which they were found. After paying a short visit to Dr. Ogier Ward's fine collection of fossils the members visited the Caldecott Museum, where they were received by Mr. F. C. S. Roper and Mr. C. J. Muller, two of the Trustees. There is here preserved an extensive collection of local fossils, a small typical collection of the fossils of other localities, and specimens illustrative of the recent botany and zoology of the neighbourhood, &c., arranged and classified by various members of the Eastbourne Natural History Society. Mr. Roper entertained the party at luncheon, at his residence, Palgrave House.

After luncheon the excavation for the new bath at "The Wish" was inspected. Here an alluvial deposit, containing land and fresh-water shells, antlers of red-deer and roe-deer, and remains of wolf, horse, ox, and pig, is seen to overlie the Gault.

The fine cliff-section of Upper Cretaceous rocks exposed between the Wish and Beachy Head was next examined. The lowest bed seen is the Gault, which is brought up by an anticlinal under the Wish Tower (Martello Tower, No. 74), a small portion only, almost unfossiliferous, being exposed. The Upper Greensand, with phosphatic nodules, and fossils only in its upper layers, is next seen. It is 30 feet thick, but thins out to about 20 feet at Beachy Head. It is a grey calcareous sandstone, gradually becoming lighter in colour and more calcareous as it passes into the Chalk Marl, which is here very fossiliferous, having a bed of calcareous sponges at its base, then several bands of ammonites, and other fossils in its higher zones.

In the extensive quarries in the Middle Chalk at Holywell, several fossils, including some fine so-called palatal teeth of *Ptychodus*, were obtained. Here a descent was again made to the shore; and in continuing the walk under the cliff to Beachy Head, the numerous faults and slickensided surfaces of the Chalk, the anticlinal near Cow Gap (which again brings up the Gault and Upper Greensand, the latter here much more fossiliferous than at the Wish), and the landslip which obscures the greater part of this anticlinal, were especially noticed; and at the farthest point reached specimens of Polyzoa and Echinodermata were collected; these abound in the lowest zone of the Upper Chalk, which here forms an almost perpendicular cliff more than 500 feet in height.

The party then returned to Eastbourne by the path along the

edge of the cliff, and in the evening attended a meeting of the Eastbourne Natural History Society, at which Mr. Dewick read a paper "On the Alluvial Beds of the Wish," preceded by a brief general account of the geology of Eastbourne.

On Saturday morning the members left Eastbourne for St. Leonards. On their arrival they were met by Mr. Peyton, who had kindly provided carriages for the day. The Old Roar quarry, an extensive excavation in the Wadhurst Clay, was first visited. Here a bone-bed, almost entirely made up of the teeth and bones of the old Wealden reptiles and fishes, is exposed. It appears to have formed the bed of a river, and may at one time have been continuous with the similar bed at the Black Horse quarry, near Battle.* Overlying the bone-bed a leaf-bed containing impressions of ferns is seen; and below it the Wadhurst Clay encloses a concretionary argillaceous limestone from three to four feet thick, for which the quarry is worked. Below this is a bed of blue clay, and then another bed of stone, the whole resting on the Ashdown Sand. Two other quarries, one in the upper part of the Ashdown Sand, the other in the Wadhurst Clay, were visited, and in each of them fossils were found.

The beautiful glen of Old Roar especially attracted attention. The stream runs along a fault, and the glen most probably owes its existence to the convergence at this spot of three faults. At Silverhill a fine section of the Tunbridge-Wells Sand was observed; and on the return to St. Leonards the party had an opportunity of observing sections of each of the beds of which the Wealden Series is composed. In descending order these are:—Weald Clay, Tunbridge-Wells Sand, Wadhurst Clay, Ashdown Sand, and Ashburnham Beds,† the last-named being probably the equivalents of the Upper Purbeck Beds of Dorsetshire. The members were entertained at dinner by Mr. Peyton.

After dinner the party proceeded westward towards Bexhill. The fault by which the Ashdown Sand is let down against the Ashburnham Beds was observed at Bo-Peep Station; and the submerged forest between Bo-Peep and Bulverhithe, which can

* (Not now to be seen.)

† Mr. Peyton informs me that since this excursion took place the Geological Survey has re-named the Ashburnham Beds the "Fairlight Clays," and that "the limestone and shale beds of Rounden Wood, Archer's Hill, Netherfield, &c., which used to be called the 'greys' and 'blues' of the Ashburnham, are now marked Purbeck," this being settled by the discovery of the gypsum at the Netherfield boring [J. H., 1873.]

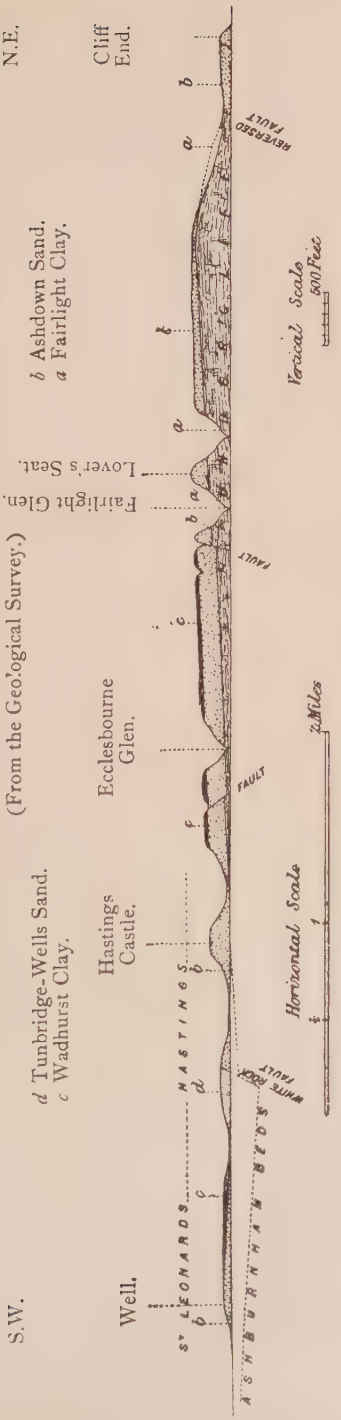

FIG. 49.—SECTION ALONG THE CLIFFS OF HASTINGS AND FAIRLIGHT.
(From the Geological Survey.)

only be seen when the tide is at its lowest, was next visited. Remains of oak, yew, hazel, and other trees, in their natural position, were seen, and a few hazel-nuts, &c., were collected. On the shore the Ashdown Sand, the mottled clays of the Ashburnham Beds, &c, were successively passed over, and in the Bulverhithe and Bexhill cliffs fine sections of these beds were observed. The sections are very difficult to work out, owing to the faults which traverse them. Numerous specimens of *Estheria* were obtained from the Ashdown Sand. In a single zone less than a foot thick this little Crustacean is especially abundant.

Tower No. 44 stands on the very edge of a lofty, overhanging cliff of the Ashburnham Beds. The mottled clays of this series are seen on the shore at low water, passing upwards into distinctly bedded sandstone, thin seams of lignite being here and there exposed; and just at the top of the cliff are the Ashdown Sands.

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EXCURSION TO HASTINGS.—1862.

(*Report by* The Rev. Alfred Deck, M.A., F.G.S.)

(*Proc. Vol.* i. *p.* 248.)

On Thursday, the 22nd of April, about fifty members spent some hours in examining the geology of the Hastings Cliffs. The services of a guide having been secured, attention was first directed to the Castle Hill Rock, showing about 90 feet of nearly pure white friable sandrock, false-bedded, on the top of which was stated to be a bed of shale, containing *Endogenites erosa*, but owing to the excavations for sand, the shale is now very much cut away.

Near the Chapel and Lifeboat Station of the Fisherman's Town, is a spring in the sandstone, the water coming through a pipe which has within the last few years been driven into the rock. Beneath this conduit is a bed of lignite, continued from behind the Castle Chapel and Pelham Crescent. Close to this spot are the curious caves formed in the sandrock about 200 feet above the beach. Proceeding eastward, the shingle no longer acts as a barrier, and the weather and sea wear away the rocks. Here the bare cliffs exhibit about 100 feet of sandrock covered with shales and limestone, and more yellow sandrock. The limestone is a thin deposit, and is the bluish-grey building-stone of the neighbourhood. It is the "calciferous grit" of Webster and Mantell, being sand hardened by carbonate of lime. Amongst the shales *Endogenites* seems to occur in great abundance. Under the white sandrock there are three or four beds of rock containing a quantity of ironstone and small seams of false coal, with shales between; these seem gradually to die away towards the east. Beneath this bedded rock are marls and shales, in which Mr. Beckles and others have discovered fine specimens of ferns. Beneath this again are beds of clay passing down to the beach, one of which is excavated for pipeclay. Eastward are still lower beds, consisting of hard irony shale: these are soon obscured by the landslip at

Ecclesbourne Glen. On the beach some capital specimens of lignite and ironstone were met with, the latter containing iron in such quantity as formerly to have rendered it worth the working as an ore of that metal. Up the glen are mottled clay beds. The sandstone rocks show excellent examples of weathering, and if these rocks are followed up still further to the eastward, the lignites and clays pass into a large series of purple clay of unknown thickness, with irregular bands of rock, arching upwards at Lee Ness, and forming the whole face at Goldbury Point. They then assume their low form again, and at Cliff End, after a well-marked fault, are succeeded by sands and sandstones, such as are seen at West Hill or Castle Hill. Up in the country these sands seem to be covered by other beds, possibly between 200 and 300 feet thick, before we get to the Weald Clay.

The members then went to the Mayor's house to examine the large footprint of the Iguanodon which the recent fall of the cliff near the town had brought to light.

EXCURSION TO BATTLE AND HASTINGS.—Easter Monday and Tuesday, April 10th and 11th, 1882.

Directors—William Topley, F.R.S., and J. E. H. Peyton, F.G.S.

(*Report by* W. Topley.)*

(*Proc. Vol.* vii. *p.* 356.)

The chief geological interest of this excursion consisted in an examination of the lowest beds exposed in the Wealden Area. These, formerly known as Ashburnham Beds, but now classed as Purbeck, are exposed along a narrow line on the north and north-west of Battle. The lowest beds of the Fairlight Cliffs were also formerly called Ashburnham Beds, it being supposed that these and the beds near Battle were on the same geological horizon. Of the correctness of this determination there have always been grave doubts, and it is now known to be erroneous.

The highlands of the Wealden Area in East Sussex are formed of sand and sandstone (Ashdown Sand) brought up along anticlinals and by faults. This Ashdown Sand is probably 500 feet thick. Its lower part is clayey, and it is underlaid (though generally with a faulted boundary) by the beds now known as Purbeck.

* A notice of this excursion appears in the "Atlantic Monthly" for Sept., 1882, from the pen of Moncure D. Conway, who formed one of the party.

The cliffs of Fairlight, east of Hastings, expose a thickness of about 150 feet of sand and sandstone (Ashdown Sand), but below this there are 360 feet, with no base reached, of sand, sandstone, and mottled clay. These lower beds are now known as the Fairlight Clays; they represent the lower and more clayey part of the Ashdown Sand of inland areas. Without doubt they overlie the Purbeck Beds, which would probably be reached at a small depth only below the centre of the anticlinal at Fairlight.

The stratigraphical evidence for the succession as now adopted is, therefore, sufficiently strong. But the Sub-Wealden Boring has shown that the lowest beds of the inland area contain important beds of Gypsum, a mineral scarcely known in the Wealden Beds proper. Beneath them come the Portland Beds. Palæontologically also the revised reading is desirable, as estuarine shells frequently occur at various horizons in the Purbeck Beds, whilst the Wealden Beds of this area are characterized by fresh water forms.*

Monday.—The party assembled at Battle Station.

After inspecting the ruins of Battle Abbey the members drove northwards to the most easterly exposure of the Purbeck Beds, at Jether Wood. Thence a short walk brought them to the tramway from the Sub-Wealden Gypsum works, by which a journey was made in waggons. Three hundred years ago Sussex was a busy centre of the iron trade, but the mineral manufactures gradually declined, and during the last 50 or 60 years these have been almost limited to lime-burning. The discovery of Gypsum, however, which is now being extensively worked, has once more placed Sussex in the list of mineral-producing counties.

The total thickness of the Sussex Purbecks is about 400 feet: 300 feet are exposed at various places; the lowest 100 feet or so are only known from the boring. Beds of limestone, once largely worked by means of pits, occur chiefly at two horizons, an upper one known as "The Greys" and a lower one called "The Blues." Below the Blues come other scattered bands of limestone, whilst lower still we have the shales with Gypsum. The Greys and the

* *Cypridea granulosa*, Sow., (*C. tuberculata*, Forbes) occurs in a light coloured limestone at Limekiln Wood, near Mountfield, in abundance. Further evidence is hardly needed, as this ostracod has never yet been found in other than *wealden* Purbeck strata. See Jones, *Quart. Journ. Geol. Soc.*, xli., 1885, p. 339 (No. 95).

beds near them are usually very fossiliferous, the lower beds much less so.

The Sub-Wealden Boring was made during the year 1872-75, chiefly through the exertions of Mr. Henry Willett, of Brighton. A good selection of the cores, with illustrative sections, is placed in the Brighton Museum.

Prof. J. F. Blake suggests the following as a possible classification of the beds passed through in the boring :—

	Thickness. feet.	Depth from Surface. feet.
Purbeck	180	... 180
Portlandian	60	... 240
Bolonian	660	... 900
Virgulian and Pterocian ...	430	... 1330
Astartian	30	... 1360
Supra-coralline	390	... 1750
Corallian	90	... 1840
Oxfordian	65	... 1905

Tuesday.—This day was devoted to an examination of the cliffs east of Hastings. The cliffs are capped by Wadhurst Clay, near the base of which are bands of clay ironstone, and a shelly band of ironstone full of *Cyrena*. These beds were the chief source of the ore of the old Wealden furnaces.

The top bed of the Ashdown Sand is massive, and forms natural rocks round the valleys. It is hard externally when weathered but inside it is soft. St. Clement's Caves at Hastings are excavated in this bed. A bed of shale, 30 feet below the top of the sands, makes a distinct feature in the cliff; it contains *Endogenites erosa*. Some interesting cases of extreme false-bedding were noticed. One of them, just east of Ecclesbourne, might be mistaken for evidence of local unconformity between the Ashdown Sand and Fairlight Clays. The characteristic mottled clays of the Fairlight group appear in quantity near and east of Fairlight Glen.

A large groyne lately built east of Hastings intercepts the travel of shingle from west to east along the coast. The western end of the town has suffered much from the rapid removal of shingle and the wasting action of the sea.

[On Whit-Monday and Tuesday, 1886, there was an excursion to *Dungeness*, *Rye* and *Hastings*, the Directors being W. Topley, F.R.S., J. E. H. Peyton, and George Wilks. A report of it may be seen in the Proceedings (vol. ix. p. 544).]

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MIDDLESEX AND HERTFORDSHIRE.

EXCURSION TO THE SITE OF THE NEW MUSEUM OF NATURAL HISTORY, SOUTH KENSINGTON.

JULY 10TH, 1875.

Director—Prof. JOHN MORRIS, F.G.S.

(*Report by* W. H. HUDLESTON).

(*Proc. Vol.* iv. *p.* 325.)

PROFESSOR MORRIS and the party were received by Mr. Thos. M. Rickman and Mr. Farquharson, who conducted them over the building now in progress.

Mr. Rickman described the plan of the building at some length, and gave details of the various apartments; after which the members inspected several of the more accessible portions.

The party then adjourned to the excavation now opened in the Thames Valley Gravels, which have, within the area, a maximum thickness of about 20 feet rather towards the eastern end, whilst on the west they are only 7 feet thick. Few organic remains have been discovered: but the tooth of an elephant, *Elephas primigenius*, was found at the west end, almost resting on the London Clay. The party then descended into the most recent excavation

in the gravels, which have the usual character of the deposits at a lower level than the Clay belt, which separates them from the Higher Level Gravels. Professor Morris gave a short account of the Quaternary deposits of the Thames Basin.

[On April 22nd, 1867, the *Thames Embankment Works* were visited, but no Report of this excursion exists.

On October 18th, 1862, the *Northern Main Drainage Works* were inspected, the party starting from *Old Ford* and proceeding towards the *Outfall*. There is a report of this excursion in Proc., vol. i. pp. 277-9, but the details are entirely of engineering, not geological interest.]

THE NORTH OF LONDON.

[No account of an excursion to *Holloway* and *Highgate* railway cuttings on June 16th, 1866, appears to have been published, but a visit to *Tottenham* on August 7th, 1869, is chronicled in an 8vo pamphlet, dated 1869, and the deposits then seen are described by H. Woodward, Geol. Mag., 1869, p. 385. It will be remembered that these last two excursions took place during the cessation of any issue of Proceedings—in the interval between the publication of vols. i. and ii.]

EXCURSION TO HOMERTON.—SATURDAY, MAY 5TH, 1883.

Director—WORTHINGTON G. SMITH, F.L.S.

(*Proc. Vol.* viii. *p.* 124.)

THE object of the excursion was the examination of the Palæolithic localities discovered in the Lea Valley. The party was met at the Homerton Station of the North London Railway by the Director, and conducted to the western bank of the Lea, where the new buildings belonging to the School Board in Sydney Road had been erected.

The river-terrace is here 33 feet above the level of the Lea, and the opposite terrace on the eastern side of the Lea in Essex was seen exactly a mile and a half away. Mr. Smith explained that other terraces were more than 90 feet higher than the surface of the Lea and correspondingly wider apart. These heights were referred to as indicative of what great change had taken place since Palæolithic times in the excavation of the wide and deep Lea Valley. The Director stated that very few implements were found in the valley lower than the 33-feet terrace on which they then stood. Stray

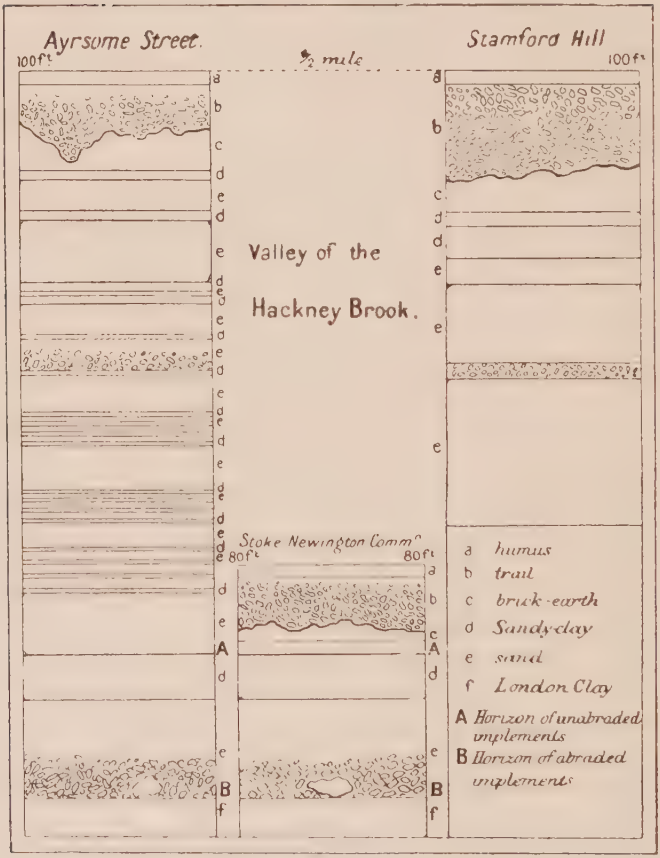

FIG. 50.—VERTICAL SECTIONS OF THE GRAVELS OF HACKNEY.

examples were now and then found in the lower levels, but the evidence indicated to him that there was some sort of break in the continuity of the Palæolithic age at the time of the formation of the 33-feet terrace. He said that the gravel and sand there seen in the open excavations was of various depths, sometimes 12 feet and at others 30 feet, and that it rested on the London Clay. The implements are not common on the 33-feet terrace, and, as a rule, they are all abraded and ochreous. Mr. Smith called special attention to the "warp and trail," the ice-deposited material which he said covered nearly all the north-east of London. This "warp and

FIG. 51.—SECTION ACROSS THE VALLEYS OF THE HACKNEY BROOK AND THE LEA.

trail" does not, however, go under the Lea; it gradually thins off further down in the valley, and by its deposition seems to indicate that it followed a natural depression belonging to an old surface into which the Lea afterwards ran. All the implements are older than the deposition of the "warp and trail," and enormously older than the Lea as known in modern and Neolithic times. As a proof that the valley had not materially changed since Neolithic times, he instanced the finding of Neolithic celts and other tools just beneath the surface *humus* at the bottom of the present valley. On the 33-feet terrace, one of the visitors found an implement, broken in Palæolithic times, in gravel thrown on a new road close to the schools.

The valley was then descended, and a pit visited almost on a level with the river, in which little of human origin had ever been found. From here the bank was again ascended to Glyn Road, Lower Clapton, and the party went to see two exceedingly fine Palæolithic implements found close by. The implements were found by gravel-diggers many years ago, and the men, not knowing what they were, were struck with their beautiful forms and geometrical precision of outline. The workmen sold them to Mr. Poole (their present owner) as ornamental objects.

The party then made their way to Clarence Road, about 57 feet above the Lea, and everywhere—on looking eastwards down the streets—corresponding heights could be seen across the Lea in Essex.

The collection of Mr. J. E. Greenhill, in the Clarence Road, was then inspected. This collection is a notable one, as it

numbers more than three hundred weapons and tools recently acquired in the Clapton district; the quest not having been commenced by Mr. Greenhill till two years after Mr. Smith's paper on the implements of the Lea Valley was read before the Anthropological Institute. Mr. Greenhill then conducted the party to the brick-pit at Upper Clapton, just east of the Clapton Railway Station. The surface here is 44 feet above the Lea, and the brick-earth is rich in Mammalian remains. These were

FIG. 52.—SECTION IN STOKE NEWINGTON PIT.

[Reprinted by permission of the Council from Q. J. G. S., vol. xxv.]

l. Surface Soil. *k.* Covering bed, large flints in stiff brown clay. [? Trail] 6-8 feet. *j.* Brick-earth. *i.-g.*, *e.-c.* Finely laminated loams and clays. *f.* Peaty black clay. Beds *c.-j.* were 30 feet thick.

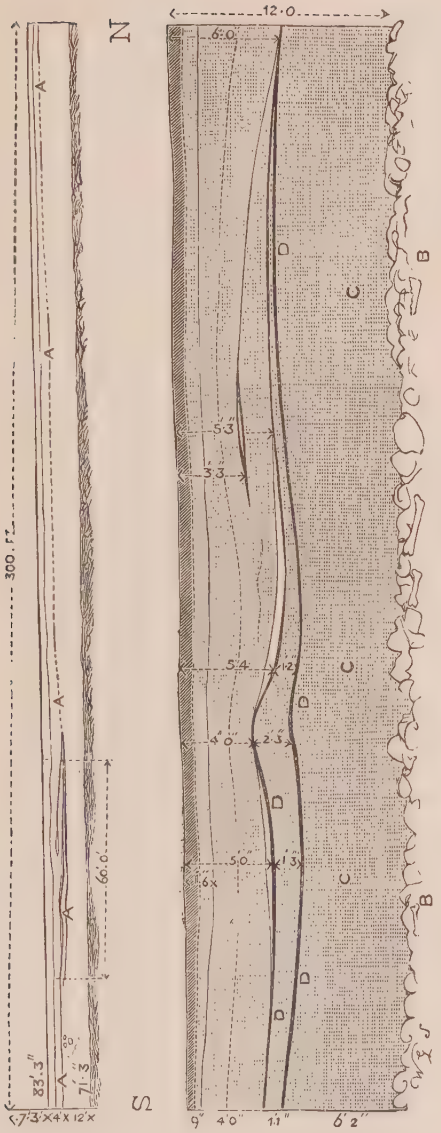

FIG. 53.—SECTION WEST OF KYVERDALE ROAD, STOKE NEWINGTON.*

studied for several years by Dr. Cooke, of Stoke Newington, and many examples from this collection are now in the Museum of Natural History at South Kensington. Mr. Greenhill explained the nature of the beds, and gave his own experience of the fossil bones contained in the brick-earth.

From these pits the party made straight for Stoke Newington Common, the scene of the more interesting of Mr. Smith's discoveries, as here he lighted on an undoubted Palæolithic settlement of great extent, the sandy floor or working place remaining to this day just as it was left by the Palæolithic men who lived on the spot before the thick, tenacious, ice-laid deposit known as "warp and trail" was deposited.

At the time of the visit the excavations were not numerous or

* Figs. 53 to 59, reproduced here by the kind permission of Mr. Worthington G. Smith, F.L.S.

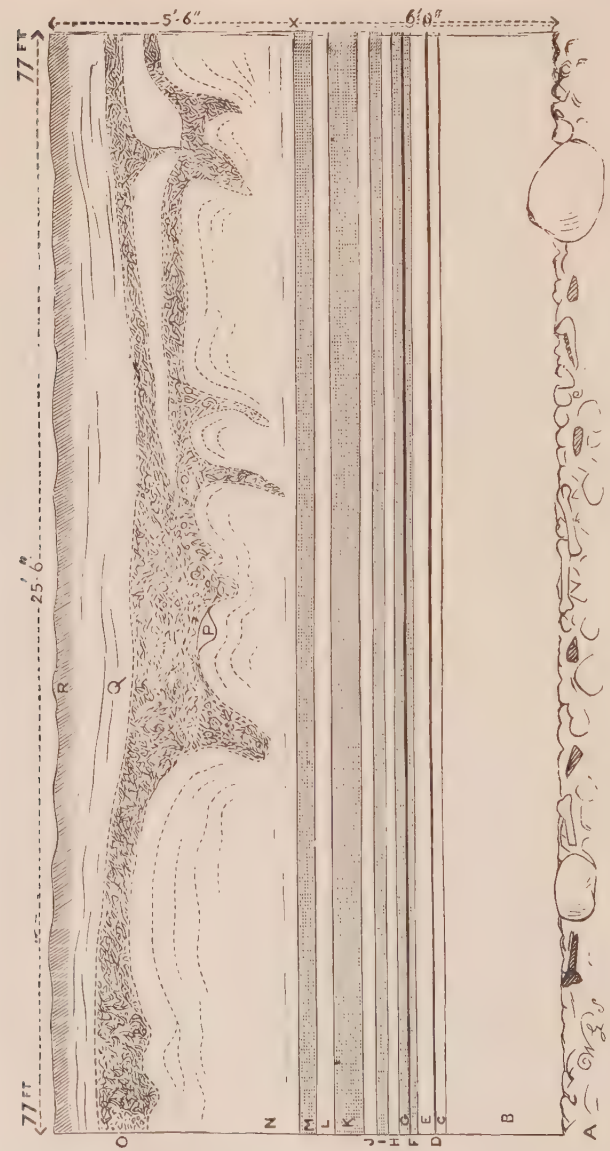

FIG. 54.—SECTION SHOWING "WARP AND TRAIL", STOKE NEWINGTON.

deep; indeed Mr. Smith explained that large and deep excavations were seldom seen. The examples open were, however, sufficient to show the nature of the deposits, including the seam

representing the "Palæolithic Floor." The accompanying illustration (fig. 53) shows a section, 300 feet long from N. to S., through the back gardens on the western side of Kyverdale Road; drawn by Mr. Smith when the excavations were made for the basements of the houses and the drains. The surface of the ground at the south is 83ft. 3in. above Ordnance Datum, and at the north 90ft. 6in. At from 4ft. to 6ft. from the surface there is a thin stratum of sub-angular flints, shown by the line A A A. This is the "Palæolithic Floor," or working-place, 60 feet of which is further enlarged to scale in the lower part of the illustration: B is Thames gravel much older than the "Floor," and containing slightly abraded lustrous implements; and C is fine sand, often full of fossil fresh-water shells, including *Corbicula fluminalis* (Müll.) and *Hydrobia marginata* (Mich.). D D D is the "Palæolithic Floor," on which rest hundreds of Palæolithic implements and flakes as sharp as on the day they were made, quartzite hammer-stones with ends abraded off, fossil-bones, antlers, teeth, &c. Above the "Floor" D D, is sandy loam, loamy sand, and distinct "warp and trail" where it has not been removed for brick-making, &c. A characteristic section of "warp and trail" is shown in fig. 54. The base, A, is generally about 12 feet from the surface, and agrees with stratum B in fig. 1. C to M are various deposits of white and coloured sand. The "Palæolithic Floor" is here almost obliterated, but its position is between M and N. The "warp and trail" is seen at O and Q, whilst P is a pocket of London Clay. R is surface *humus*, containing Neolithic implements, bone tools, British and Roman pottery, Roman coins, and other objects of more recent date.

FIG. 55.

FIG. 56.

Fig. 57.

Fig. 59.

Fig. 58.

Figs. 55 and 56 illustrate two small and beautifully-made implements, and fig. 57 an abraded quartzite hammer-stone; all one-half real size, and (except fig. 56) now in the collection of Dr. John Evans. The implements from the twelve-foot stratum of Thames gravel are sub-abraded, lustrous and of greater age than the foregoing; one of these, now in the collection of Dr. Evans, is illustrated, one-half real size, by fig. 58. At depths of 20 feet, and sometimes 30 feet, other gravel occurs with still older, more greatly abraded, and ochreous implements; one of which, from the east side of the Lea, at Leyton, Essex, is illustrated at fig. 59. The localities and implements have been described and illustrated by Mr. Smith in "Nature" (Oct. 12, 1882, and Jan. 18, 1883), and more fully in the "Trans. Essex Field Club," vol. iii. part 7. Mr. Smith directed special attention to a small excavation at the S.W. end of Kyverdale Road, partly filled in with surface *humus* at the time of the visit, where the line of the "Palæolithic Floor" was defaced by the material which had been thrown in. When this small excavation was re-opened a few days after the visit the workmen lighted on many excellent implements and flakes, at least ten or a dozen of the former, and more than a hundred of the latter. Three or four of the implements were the finest yet found in north-east London; these were acquired by Mr. J. E. Greenhill. North-east London has produced nearly 1,000 implements since 1878 [to 1883].

From Kyverdale Road the party walked to Mr. Smith's house at Highbury, where about 1,100 implements had been laid out for inspection. These included 300 or 400 from the localities visited during the afternoon, and others from nearly every known locality in England. Hammer-stones, scrapers, cores, &c., from the "Palæolithic Floor," were also laid out so as to be easy of inspection, together with fossil bones (including the scapula of a Mammoth in contact with an unabraded implement), flakes, drift-wood, fossil shells, and two scraper-flakes which had been struck from the same block of flint in Palæolithic times, and had been replaced by Mr. Smith.

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EXCURSIONS TO HAMPSTEAD.

[The Association visited *Hampstead* for the first time on June 11th, 1870, when the collection of the late Mr. Caleb Evans was also inspected. A brief report appears Proc. vol. ii. p. 14.]

EXCURSION TO HAMPSTEAD.—April 27th, 1872.

Directors—S. R. Pattison, F.G.S., and Caleb Evans, F.G.S.

(*Report by* Caleb Evans.)

(*Proc. Vol.* iii. *p.* 67.)

The party assembled at the Swiss Cottage Railway Station.

On reaching the fields by the shaft of the Midland Railway tunnel near Belsize Lane, Mr. Pattison explained that the lower parts of the district consisted of London Clay, and that the upper part of the hill was composed of sand, which was an outlier of the lower part of the Bagshot Sands. This porous sand acted as a kind of sponge and the water which percolated through it, being upheld by the impervious London Clay below, appeared as springs on the sides of the hill. These springs served as a good indication of the junction of the two formations.

No animal remains (with the exception of a few casts of shells and some rare indications of fishes) have been obtained from the Bagshot Sand in the London Tertiary area, but in Sussex the Bracklesham Beds—the equivalent of a part of these sands—contain a very varied fauna, which is perhaps only exceeded in richness by that of the Calcaire grossier of the Paris Basin, a deposit of probably the same age. Equivalent strata are also seen at the Hill of Cassel in the north of France, from which spot Mr. Pattison had obtained *Cerithium giganteum* of large size.

Mr. Evans then, with the aid of sections and a large geological map of Hampstead, explained the geology of the district, and stated that the stiff London Clay passed in its upper part into a

sandy clay which formed the hill at a definite level.* Fossils were very abundant in this sandy clay, especially *Pectunculus decussatus* and *Voluta nodosa*. These shells had been obtained from the spot where the visitors were then assembled, the lower part of this stratum having been traversed in the shaft of the Midland tunnel.

The party then proceeded to the Conduit Spring, which indicated the presence of the Bagshot Sand, and by the aid of an aneroid barometer it was shown that the "Pectunculus-bed" was about 50 feet in thickness.

The drains in course of construction in the Greenhill Road exposed a good section of the sands; and the party then followed, as nearly as possible, the line of junction of the sand and clay, which was indicated by pools of water in Gayton Road, by the chalybeate spring in Well Walk, and by the springs near the pond in the Vale of Health.

The character of the valleys, which were observed to radiate from the central plateau of sand, was noticed, and the party ascended to the higher ground and examined the sand there exposed in pits.

In the large sand-pit on the top of Hampstead Heath, opened a few years since for the purposes of the Midland Railway, attention was particularly directed to the gullies or small ravines which had been excavated since that time by the action of the rains falling on the surface and percolating through the porous deposit until checked by the thin bands of sandy clay which are interstratified with the sands. It was suggested that these ravines furnished an illustration of the process by which the diverging valleys around Hampstead had been formed.† It was also suggested that the flint pebbles, scattered over the surface of the heath, might be the remains of higher strata, which had been removed by the gentle but powerful action of subaerial denudation.

From the Mound, near North End, the geological character of the country to the north was explained. The high range of hills by Bushey and Elstree forms the northern escarpment of the London Clay, and the intervening range of hills by Hendon and Finchley is capped by Glacial clays and gravels resting on an eroded surface of the London Clay.

On the West Heath the position of the junction of the Bagshot Sand and the London Clay was again seen, and the spot by the

* See Fig. 60, p. 142.

† See Proc. Geol. Assoc., vol. iii. p. 31.

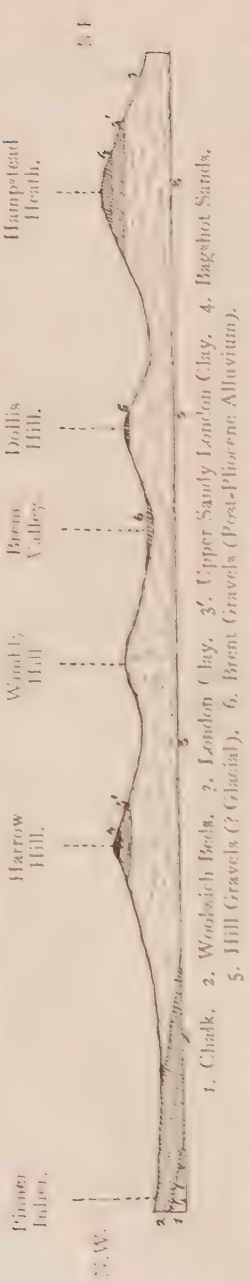

Pinner Inlier.
Harrow Hill.
Wood Hill
Brent Valley
Dollis Hill.
Hampstead Heath.
N.W.
S.E.
1. Chalk. 2. Woolwich Beds. 3. London Clay. 3'. Upper Sandy London Clay. 4. Bagshot Sands. 5. Hill Gravels (? Glacial). 6. Brent Gravels (Post-Pliocene Alluvium).

FIG. 60. SECTION FROM PINNER TO HAMPSTEAD (1 INCH TO 2 MILES). BY J. L. LOBLEY.

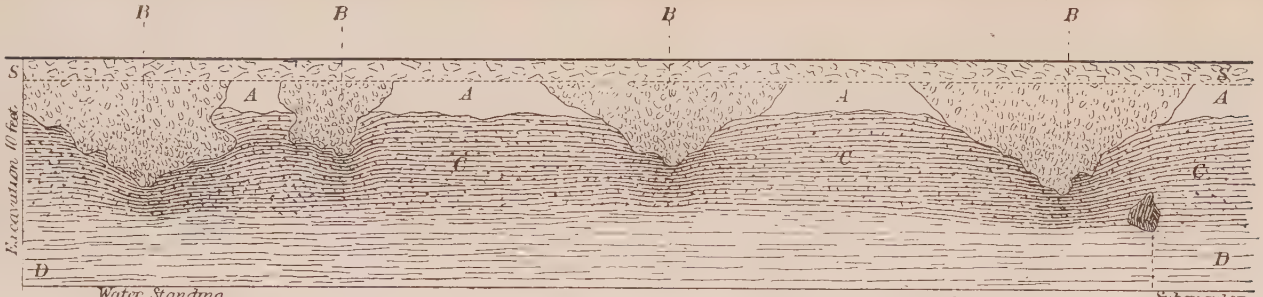
Leg of Mutton Pond, where *Pectunculus decussatus*, &c., had been obtained during drainage excavations, was pointed out.

In order to afford the members an opportunity of observing the effect produced on the surface by the superposition of the water-bearing sand above the London Clay, they were then conducted across the swamp which occurs in the lower parts of the West Heath Valley.

[The next excursion to *Hampstead* took place on June 22nd, 1874, Caleb Evans again being Director. There is a very brief report of it in Proc. vol. iv. p. 155. Mr. Evans also conducted another party of the Association to *Hampstead* on June 10th, 1877, from the report of which the following details are taken. (Proc. vol. v. p. 100.)]

The absence of any clear sections of the Lower Bagshot Sand or of the London Clay obliged the party to confine their attention chiefly to the geological structure of the surrounding district, and having proceeded to the top of the hill by the flagstaff, the positions were pointed out of Harrow-on-the-Hill with its small outliers of Bagshot Sand, of the high ridges above Stanmore, Elstree, Highwood Hill and Mill Hill capped with patches of Pebble-gravel of doubtful age, and of the intervening district around Hendon and Finchley, on which Glacial deposits yet remain. From the neighbourhood of North End the difference was noted between the prospect to the northward, where the district occupied by

FIG. 61.—THE MOUNT, EALING. EXCAVATION OF THE SOUTH SIDE, OCTOBER, 1882.



	Feet.
S. Surface soil very full of stones	¾
A. Mottled Clay, "puddled"	2-3
B. Channels filled with Gravel, Stones, Clay (some probably 130-150 ft. long)	3-5
C. Laminated Loamy Clay and Sand, dripping slightly *S.*	5
D. Very Loamy Clay, with sandy layers, Mica and Sarsens.	
E. Strong Loamy Clay, with Mica.	

Boring 10 Feet.

E

FIG. 62.—SECTION AT THE MOUNT, EALING. (About 50 feet long.)

* Included mass of sand. ** Included deposits of Purple Clay.

the Glacial deposits presents the appearance of a wide and level plateau as far as the eye can reach, and the view to the north-west of Hampstead, where the country is composed of London Clay with small cappings of sand or gravel, and is more diversified by detached hills and intervening valleys. In the immediate neighbourhood of the heath the diverging valleys occupied by the Hampstead and Highgate ponds, forming the headwaters of the Fleet river, were noticed, as probably resulting from the outflow of springs at the junction of the London Clay with the Bagshot Sands. Examples of these springs were well seen at the Vale of Health and at Well Walk, and after tasting the chalybeate water at the latter spot, the party proceeded to the residence of the Mr. Evans, and examined his collection of Tertiary fossils, many of which were obtained by him in the neighbourhood of Hampstead.

[An excursion to the *Brent Valley and Hampstead* took place on May 7th, 1887, J. Logan Lobley being Director. An account of it may be read in the Proceedings, vol. x. p. 148. In the same part may also be seen the report of an excursion to *The Mount, Ealing, and Horsington Hill*, on June 18th, 1887, J. Allen Brown, Director.]

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EXCURSION TO PERIVALE.—Saturday, May 26th, 1883.

Director—Rev. Prof. Henslow, M.A., F.G.S.

(*Report by* The Director and Prof. T. Rupert Jones, F.R.S.).

(*Proc. Vol.* viii. *p.* 141.)

The members were met at Ealing Station by Prof. Henslow and Mr. J. Allen Brown, under whose guidance the party proceeded to the New Reservoir now in course of construction on the Mount. Here cuttings were visible, showing waved and banded loamy strata with deep grooves in them, the strata bending under the grooves. The latter run in a northerly direction, and were believed by Mr. Brown to be due to ice-action, as several specimens of rocks of various kinds had been found scattered about the surface of the field ; but the grooves themselves appeared only to contain water-worn flints, and not rocks indicative of ice-action. A discussion arose as to their truly glacial character, Prof. Rupert Jones inclining to the idea that the upper beds had *sunk* over subterranean watercourses, and that the grooves were not due to ice at all.

The party proposed going to the most elevated point in the district, Horsenden Hill, but the weather proved so rainy and unfavourable that, after having visited Perivale Church and Churchyard, where the altar-tomb of Robert, son of Richard Cromwell, contains some fine *Orthocerata*, and where another old altar-tomb and its wrought iron railings have been curiously pushed and twisted out of shape by an ash, a thorn, and an ivy, they did not proceed further than the little bridge over the Swilley half-a-mile on the road beyond, where Prof. Rupert Jones gave an exposition of the physiography of the district.

He pointed out that valleys are the leading characters of a district, being the indications of the great denuding agents, rain, rivers, and ice, which modified plateaux and plains, leaving the hills as wrecks and relics of once broad flat lands. Such a land once existed throughout a great part of south-east England and north-west France, and, after the final elevation of the Weald area, wide level tracts, consisting of Tertiary strata variously eroded and coated with gravel, remained to be acted on by the retreating waters (whether the land rose, or the sea was withdrawn by its being evaporated and stored up as ice at the poles). Bagshot Heath, and other such small plateaux, and Highgate, Hampstead,

and other such hills, are local remnants, their isolation having been made more and more distinct, after tidal action ceased to affect them, by rain and rivers, aided by arctic winters; derivative or secondary gravels, thus formed in the valleys, were again and again worn down or moved away, as the hill-sides and valley-bottoms were modified; and such successional deposits of gravels, with or without the loams of flood-muds, are traceable, and have been traced as well in the Ealing as in other districts. The animals inhabiting the lands bordering the sea-creeks, lakes and rivers were drowned and imbedded there and then, and tell of warmer or colder climates, as the case may be; and in many cases the flint tools and weapons of man are found in the gravels along certain stages or horizons of these diluvial and alluvial deposits; Mr. Allen Brown and Mr. R. W. Cheadle have found such archaic implements near Ealing, and others are abundant at Acton and elsewhere.

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Map.—See Excursion to Hampstead (p. 144).

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FINCHLEY AND NEIGHBOURHOOD.

[The first excursion to this district was made in 1866, and was unrecorded in the Proceedings.]

EXCURSION TO HENDON AND FINCHLEY.

June 22nd, 1872.

Director—Dr. Henry Hicks, F.R.S.

(*Proc. Vol.* iii. *p.* 115.)

The party assembled at Hendon station, and proceeded to the village of Hendon, upon the high ground, to the east. The London Clay is here capped by Glacial deposits, which form the

summits of the eminences lying between the Bagshot outliers of Hampstead and Highgate and the elevations of London Clay extending along the borders of Middlesex and Hertfordshire.

Dr. Hicks led the way to some recently excavated pits, where good sections were exposed. Here he pointed out the very marked resemblance of the beds at this place to the Thames low-level sands and gravels of Post Glacial age. Luncheon was kindly provided by Mr. James Campbell, of The Grove, Hendon.

The members then proceeded to the residence of Dr. Hicks, who had arranged his collection of Cambrian and Lower Silurian fossils on tables in his grounds for the inspection of his visitors. The large trilobites *Paradoxides Davidi* and *P. Hicksi*, from the Menevian rocks of St. David's, attracted great attention, and the number, variety, and good preservation of the Cambrian fossils surprised many of the visitors.

The party, on leaving, followed for a short distance the lane leading to Finchley, and then turned aside to some extensive excavations where the Glacial beds were exposed to a great depth, and the underlying London Clay was seen in a sinking at the bottom of the pit. Here the "Middle Glacial" of Searles Wood is seen underlying the Chalky Boulder-Clay, which forms the upper portion of the section. Mr. Caleb Evans and Mr. C. J. A. Meyer briefly described the geology of the district, and discussed the origin of Sarsen stones, some of which masses of sandstone were lying around.

After a walk of about a mile Finchley was reached, and the exposures of Glacial deposits near the village were examined. These are described in Henry Walker's paper "On the Glacial Drifts of North London" (Proc. Geol. Assoc., vol ii. p. 289). Derived fossils, especially *Gryphæa incurva*, from the Lower Lias, are abundant, and some time was spent in obtaining specimens of these suggestive memorials of great terrestrial changes.

EXCURSION TO FINCHLEY.—May 31st, 1873.

Director—Henry Walker, F.G.S.

(*Report by* The Director.)

(*Proc. Vol.* iii. *p* 214.)

From East End station the company retraced their route for a short distance, and stood on the lofty railway embankment over the valley traversed by Mutton Brook, in order to survey the

geographical features of the Finchley district, in so far as those features have been determined by the Glacial Beds. By the aid of an enlarged copy of part of the Geological Survey Map (Superficial Deposits), the Finchley Glacial District was seen to form a roughly triangular plateau. The base of the triangle runs nearly due east and west—from Muswell Hill nearly to Hendon—whilst the apex is found near East Barnet. The base and western side of the plateau were seen to be bounded by well-marked valleys, which define the limits of the Glacial beds and tell of the meteoric agencies which have helped to reduce them to their present limits. Descending the embankment the party crossed the valley and entered upon Glacial ground, each member receiving a copy of the enlarged map already described. A halt was made at Marylebone Cemetery, where, at the lodge gates, were seen a number of the characteristic drift fossils of the district, especially gryphæas, belemnites, and ammonites, which are yielded plentifully from the Boulder Clay at this spot. The excursion was then continued past the Manor House moat and pond, across the Edgware and Highgate Railway to the Manor brickfield, Finchley. Here, by the courtesy of Mr. Charles Plowman, the proprietor, some interesting sections were open to inspection. Mr. Walker then proceeded to explain the nature and review the history of the exposed deposit—the Boulder Clay of the south-east of England. The accumulations at this spot belong to the period of the great submergence of England beneath the Glacial sea, and are not the immediate products of land-ice. The relation of the Finchley and Muswell Hill Glacial Beds to the Essex outliers of the same deposits was then exhibited, Mr. Searles V. Wood, jun., having kindly forwarded to Mr. Walker his Drift Map of Essex for this purpose, as well as numerous sections across the valley of the Lea, showing the former connection of the deposits now divided by that valley. At the conclusion of the address a collection of fossils, obtained by Mr. Plowman from the pit in which the company were assembled, was exhibited by that gentleman; after which the members themselves made a successful search, many fossils from the Oxford Clay, Lias, Oolite, and Chalk being discovered, as well as rocks of great variety, including striated chalk pebbles and boulders. The party subsequently proceeded to the higher ground, near Finchley Station, facing Mill Hill, where Mr. Caleb Evans described the physical features of the country, and exhibited sections illustrative of the range and outcrop of the various formations.

[There was an excursion to *Whetstone* and *Finchley* on April 23rd, 1887, the Directors being J. G. Goodchild and H. B. Woodward. A report of it may be seen in the Proceedings (vol. x. p. 145). *Pinner* was visited on June 26th, 1886. For report see Proc., vol. ix. p. 548.]

References.

Map.—See Excursion to Hampstead, (p. 144).

Books.—W. Whitaker, Geology of London, 2 vols., 8vo, *London* (Geol. Surv.). 1889. 11*s*. [For literature.]

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H. Walker, The Glacial Drifts of Muswell Hill and Finchley, 8vo, *London*. 1874.

EXCURSION TO RICKMANSWORTH.

Saturday, June 17th, 1882.

Directors—W. Whitaker, F.R.S., and John Hopkinson, F.G.S.

(*Report by* The Directors.)

(*Proc. Vol.* vii. *p.* 397.)

The Harefield Chalk-pits, close to the river Colne, below Rickmansworth, expose as fine sections of the Upper Chalk as any to be met with on the northern side of the London Basin, and nowhere can better examples of pipes in the Chalk be seen than in one of these pits, while the absence of any vestige of a pipe in the other affords an instructive lesson in physical geology. But scant notice, however, of these sections has hitherto been taken.

After leaving Rickmansworth station the first place visited was an old Chalk-pit on Stocker's Farm, of very little interest.

Proceeding down the valley of the Colne, a short walk along the towing-path of the canal brought the party to the first of the large Chalk-pits to be visited, on the left bank of the river. The Upper Chalk here is bare, and of a pure white, the clayey beds which come on just above having thrown off the water falling upon them, thus preventing it from percolating into the Chalk, and giving rise to pipes.

The next pit, a field's length farther south, by the old "Copper Mills," was soon reached, and formed the principal

point of interest. Here the whole section of the Chalk, which presents an almost vertical cliff from 90 to 100 feet high, is irregularly capped by gravel, from which pipes, often of most fantastic shape, and of roughly cylindrical form, extend downwards to distances varying usually from 30 to 70 feet. A mass of white Chalk, of such a height and extent as, but for these pipes, would here have been exposed, would have had a most dazzling appearance; but the whiteness of the Chalk is subdued by the darker colour of the pipes, which appear to occupy almost as much space on the surface of the vertical sides of the pit as the Chalk itself.

Mr. W. Whitaker explained the mode of origin of these pipes. They were, he said, holes or hollows in the Chalk filled in by gravel or sand from the beds above. In old books they were sometimes stated to have been formed by sea-action, but such was not the case. They were caused by rain, which, in passing through air, absorbed carbonic gas, a gas which, in solution in water, had the power of dissolving the hardest limestone. The water, charged with carbonic acid gas, sank down through some line of weakness in the Chalk, along which it gradually dissolved the rock, until at last the overlying gravel and sand sank into the cavity thus formed. Here and there a mass of gravel was to be seen, which appeared to be unconnected with the pipe immediately above it, this appearance being due to the Chalk not always having been worn away in a vertical line, so that the connecting link of the pipe was not to be seen; and this was the explanation of the apparently isolated masses of gravel frequently seen in the Chalk. Where there was a mass of Tertiary clay on the Chalk there were generally no pipes, for the clay being impermeable prevented water from getting through into the Chalk; whereas water percolated through gravel, forming these pipes, in which might frequently be seen angular chalk-flints, not worn at all, and nearly in the position they occupied before the Chalk in which they were embedded was dissolved away. The gravel here forms part of a high terrace that occurs over the plateau above the pits, hiding the junction of the old Tertiary beds and the Chalk, and it is supposed to be of Glacial age, because it is like other gravels near which run under the Boulder Clay; for such detached masses of gravel were presumed to be of the same age as the larger masses, of which they seemed to be outliers.

A walk across the fields brought the party to Woodcock Hill

FIG. 63.—SECTION ALONG THE NEW LINE FROM PINNER TO RICKMANSWORTH.

Horizontal scale—1 inch = 1 mile. Vertical scale—1 inch =528 feet.

a. Alluvium. *b.* Brick Earth. *c.* London Clay. *d.* Reading Beds. *e.* Chalk.

The level of the line is approximately (from aneroid measurements) 190 feet above ordnance datum at Pinner, 230 feet at the highest point, near Grove Green, and 200 feet at Moor Farm.

Kiln. Here the section exposed was found to be better than when noted by the Geological Survey some years ago, the beds now seen in the upper pit being as follows :—

	Clayey Gravel, resting in hollows in the bed below.
Basement-bed of the London Clay.	Brown and grey sandy Clay, with a ferruginous bed in which a cast of *Panopæa* was found. ? 5 feet.
	Layer of Flint-pebbles.
	Brown Loam, about 3 feet.
Reading Beds.	Mottled plastic Clays, thick.

A small lower pit showed about 10 feet of brown sand, with clay above, and some apparently in it. This sand also belongs to the Reading Beds, and must dip under the mottled clays. The surface of the sand was very hard from exposure. The gravel is apparently part of the same bed as that on the top of the Chalk near Harefield. This section presents a rather unusual feature in a pebble-bed in the midst of the basement-bed of the London Clay, and none at the bottom. The mottled clays below, Mr. Whitaker stated, were unfossiliferous, there being nothing like them at Woolwich, &c., where the Woolwich Beds contain many kinds of fossils.

In crossing the fields from Woodcock Hill to Rickmansworth, on the summit of a hill from which was obtained an extensive view over the valleys of

the Colne, Chess, and Gade, a bed of pebbly gravel was examined. This, Mr. Whitaker said, must be as old as Middle Glacial, and might be older than Glacial, and he pointed out the difficulty, and sometimes the impossibility, of definitely fixing the age of such isolated masses of gravel. We have here the usual features of a gravel-capped hill, a flat top and a steep slope. The stones are nearly all water-worn, not angular, mostly of flint, but some of quartz.

From Rickmansworth station the train was taken to Watford, Dr. A. T. Brett having invited the party to tea at his residence, Watford House.

[There was also an excursion to *Rickmansworth* on June 4th, 1887, John Hopkinson being Director. It is reported in the Proceedings (vol. x. p. 163). Another, under the guidance of the same Director, took place on June 30th, 1888, and is reported in Proc. vol. x. p. 499.]

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W. Whitaker, The Geology of London Basin (Geol. Surv.). 1872. 13*s.*
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J. Hopkinson, Numerous Papers in Trans. Herts. Nat. Hist. Soc.

EXCURSION TO WATFORD, June 23rd, 1870.

Director—John Hopkinson, F.G.S.

(*Report by* The Director.)

(*Proc. Vol.* ii. *p.* 43.)

On alighting at Bushey Station the party examined the Chalk-pit close to the railway. A good section of the Upper Chalk, on which Watford is situated, is here seen, and overlying it, a pebble-bed of the Woolwich and Reading Series has recently been exposed. This bed completely thins out in the pit, and is succeeded by clay-drift and sandy gravel which repose, in other parts of the pit, immediately on the chalk. The Chalk Hill Pit, which

furnished instructive examples of "pipes," was next noticed, and then the party proceeded to Watford Heath Kiln, where they were joined by Mr. W. T. Stone, who showed the sections then exposed, and explained how they varied in parts of the pit not now worked. Professor Morris had previously explained the general features of the country, especially with reference to the form of the ground and general contour of the hills, as caused by denudation acting on what were originally lines of weakness.

The London Clay, with its basement-bed, and between it and the Chalk a series of beds of sand and clay (with associated pebble-beds), belonging to the Woolwich and Reading series, are here seen.

The following section is slightly altered from one given by Mr. Whitaker, in the "Memoirs of the Geological Survey" (No. 7), and reprinted in vol. iv. :—

			ft.	in.
London Clay.		*a.* Brown clay, with selenite (no fossils)	9	0
	Basement Bed.	*b.* Brown sandy clay with selenite, numerous fossils, and at the bottom a layer of shells	5	0
		c. Flint pebbles, with sharks' teeth (*Lamna* and *Otodus*)	0	3
		d. "Brown sandy clay, more sandy than the upper bed, with iron sandstone, and a little ironstone at the base. At the top, here and there, a bed of soft clayey sandstone, bored by *Lithodomi*, from 6 inches to a foot thick"	7	0
		e. Flint pebbles with oyster shells (*Ostrea Bellovacina*, Lam.)	0	3
Reading Beds.		*f.* Grey and mottled clay, with a few small pebbles	3	6
		g. Light-coloured sand	16	0
		h. Sand, with beds of pebbles	9	0
		i. Mixture of sand and clay, light coloured	3	0
		Not shown—to the Chalk	6	0

The shells at the bottom of the bed *b* are mostly in fragments, but several perfect specimens of the following, amongst other species, were collected:—*Aporrhais Sowerbyi*, Mant., *Cyprina Morrisii*, Sow., *Cyrena cuneiformis*, Fér., *Cytherea obliqua*, Desh., *Natica labellata*, Lam., *Nucula* sp. (? *margaritacea*, Desh.), and *Panopæa intermedia*, Sow. But the best collection of fossils was made from some tabular masses, or concretions, of calcareo-argillaceous sandstone occurring at intervals in this bed, but not seen in place, the section from which they were obtained not having been worked for some time. In *d*, Mr. Stone has found several rare fossils, amongst which some turtle bones and a mammal's

FIG. 64.—BUSHEY KILN.

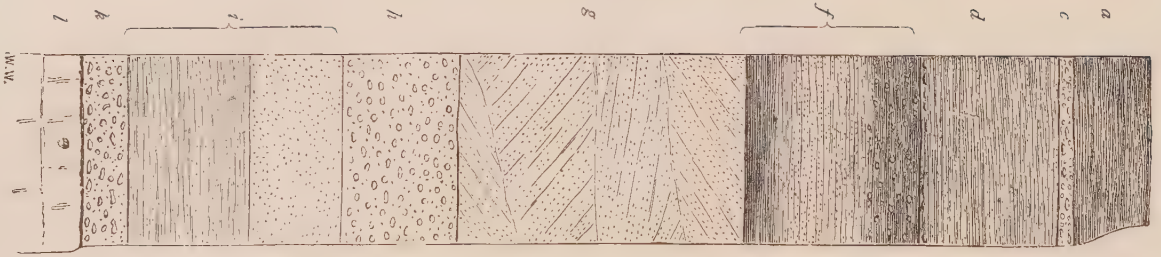
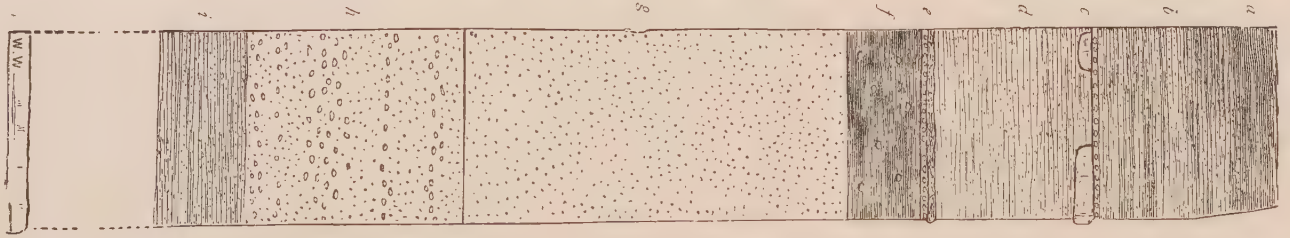


FIG. 65.—WATFORD HEATH KILN.



a. Brown Clay. *b*. Brown sandy Clay, with Shells. *c*. Pebble-bed (Fossils at Watford). *d*. Brown sandy Clay, with Sandstone. *e*. Flint Pebbles, with Fossils. [London Clay.] *f*. Coloured Clays. *g*. Light coloured Sand. *h*. Sand, with Pebbles. *i*. Sand and Loam. *k*. Flints in Sand. [Reading Beds.] *l*. Chalk, with Flints.

[These two blocks kindly lent by the Herts. Nat. Hist. Soc.]

tooth (*Hyracotherium leporinum*, Owen) were particularly noticed.

On leaving this interesting pit the party proceeded to Bushey Kiln, where a section, somewhat similar, but with an additional bed of clay with "race," and showing in the lower portion alternating beds of sand and pebbles, is exposed.

At Berry Wood, near Aldenham, the Chalk is covered by thick beds of gravel, and by the roadside some Silurian and other boulders, one deeply scratched, attest the proximity of the Boulder Clay, which, in Bricket Wood, about three miles to the north, is from 20 to 30 feet thick. In Berry Wood is a chalk-pit abounding in the remains of sponges, surrounded by mere shells of flint, and containing spicules, Foraminifera, and Polyzoa, beautifully preserved.

EXCURSION TO WATFORD, April 13th, 1872.

Directors—W. Whitaker, F.R.S., and John Hopkinson, F.G.S.

(*Report by* John Hopkinson.)

(*Proc. Vol.* iii. *p.* 65.)

The members assembled at Watford Station and proceeded northwards along the main line of the London and North-Western Railway to the cutting leading to a tunnel which is now being constructed to take two additional lines of rails. The new cutting, which diverges slightly from the old one at about half a mile from the station, exposes a section of the Chalk overlaid very irregularly by a thick bed of gravel, composed of sub-angular flints derived from the Chalk, of rounded flint pebbles also originally derived from the Chalk (but owing their present form to the attrition they have undergone in the older Tertiary rivers and seas), and of pebbles of very ancient rocks, some of which were derived from the conglomerates of the New Red Sandstone. Here and there also, in the gravel, more or less regularly stratified beds of sand divided by layers of pebbles are seen.

Before leaving this section Mr. Whitaker explained some of the chief features of this gravel, which he considered to be of Glacial age, and referred to a few of the most interesting problems connected with it. He stated that although we have in the section here exposed no certain data to determine the age of the gravel, we find elsewhere lying upon it patches of Boulder-Clay, showing that, as this gravel was deposited before the Boulder-Clay,

the Chalk, which here was originally some 100 feet (or more) thicker than now, was denuded to this extent before, or during, the Boulder-Clay period. The sub-angular flints were not considered to have been derived from the Chalk upon which they immediately lie, but to have been drifted, most probably partially at least by the action of ice, from other localities, being here deposited, together with the Tertiary flint pebbles, and the pebbles of quartz and other rocks ice-borne from the conglomerates of Worcestershire and Warwickshire, in shallow water where the currents were shifting. After the Chalk had been, as it were, planed down to its present thickness the gravel was deposited pretty regularly upon it: the present uneven surface being in great part due to the dissolving away of portions of the Chalk by the percolation through the overlying porous bed of water charged with carbonic acid, the carbonate of lime being carried off in solution as a bi-carbonate. Thus are formed in the Chalk what are called pot-holes or pipes. Wherever the water can get away, as through cracks in the Chalk, it is evident that this decomposition will take place, the gravel sinking into the hollows thus formed.

The party then left the cutting at the mouth of the tunnel and proceeded direct over the old tunnel and through the woods to Cassiobury Park, permission to pass through the private grounds of the Earl of Essex having been received.

The party took the nearest path across the park and over the fields, and on re-assembling at Watford Heath Kiln, Mr. Whitaker described the section there exposed, and a few fossils were found; Mr. W. F. Stone also distributing several fossils which he and his workmen had obtained. These principally consisted of sharks' teeth, which occur in considerable abundance in the upper of two pebble-beds forming part of the Basement-bed of the London Clay: a few only being found in the lower bed. There were also a few oyster-shells which are here only known to occur in the lower pebble-bed.

Since this section was last visited by the Association a well has been sunk through the Woolwich and Reading Beds to the Chalk, just on the edge of the mottled-clay, which here ends abruptly, its place being taken by the bed of sand on which it rests: the Basement-bed reposing in one part of the pit immediately on the mottled-clay, and in another on the sand.

After a short walk across the fields, Bushey Kiln, the last section visited, was reached. The chief point here noticed was

the great difference of the section of the Woolwich and Reading Beds from that exposed at Watford Heath, showing how very irregularly these beds were deposited. A small section, exposing several layers of pebbles in sand, showed how this difference might be partly accounted for. Not only were these layers very irregularly distributed, but between each more or less horizontal layer were to be seen thin connecting layers of pebbles passing through the sand at various angles, showing how, subsequently to the deposition of each layer of sand, strong counter currents tore up the underlying pebbles and re-deposited them at various angles. So it is, and so we should expect it to be in fresh water or estuarine strata; here sand deposited, there pebbles; at one place clay, at another loam. How very different this from the uniformity over large areas frequently presented by marine strata, such as the London Clay above, and the Chalk below!

EXCURSION TO WATFORD.—May 1st. 1875.

Directors.—Dr. John Evans, F.R.S., Prof. John Morris, F.G.S., and John Hopkinson, F.G.S.

(*Proc. Vol.* iv. p. 284)

In consequence of very unfavourable weather, the programme of this excursion was shortened. After assembling at Holly Bank, the residence of Mr. Hopkinson, the party crossed the country to the east of Watford, through which runs the Colne, in a Chalk valley with an alluvial bottom and slopes covered in places with gravel. On the further side of this valley, Professor Morris, illustrating his remarks by specimens taken from the spot, described the gravel as Drift re-arranged and re-distributed by fluviatile action, since not merely rolled portions of flints, but sub-angular pebbles of quartzite, sand-stone, lydian-stone, and fragments of other rocks, found only at considerable distances to the north and west, occur abundantly in the gravels of this and other valleys subsidiary to the great Thames Valley.

At Berry Wood a pit exposes the Chalk, with a very irregular surface, underlying a capping of Drift. Dr. Evans interested the party by producing perfectly regular cones from Chalk flints, by simply striking the flint nodules sharply with a hammer, the impact of the hammer causing an increased density of the particles composing a cone the apex of which is the point of impact.

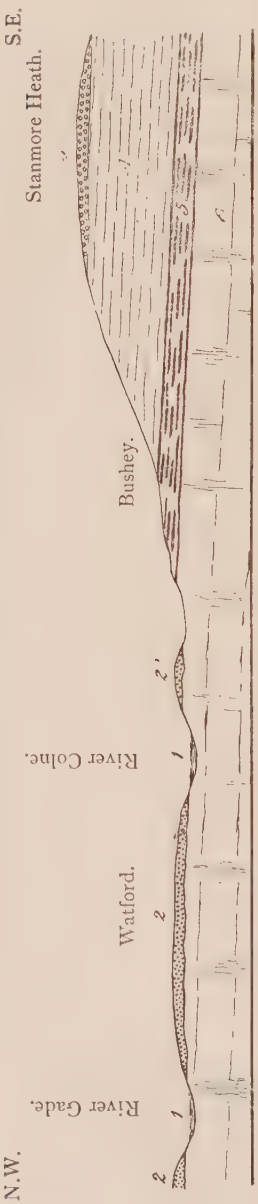


FIG. 66.—DIAGRAM-SECTION THROUGH WATFORD AND BUSHEY. (LENGTH ABOUT 6 MILES.)

This Chalk-pit is close to the river Colne, which at this place runs parallel with, and at a short distance from, the northern edge of the London Tertiary Basin. The Colne receives the rainfall of a considerable Eocene area, which, after percolating through the Drift and Lower Eocene sands, passes into the Chalk, and subsequently makes its way into the river, in some cases by springs in or close to its bed. In the grounds of Otterspool are several of these springs, giving forth never-failing streams of clear water. Six are at the bottom of the pool, and, together, yield a very large quantity of water a day, forming a not inconsiderable affluent of the Colne. The party, through the kindness of Mr. S. T. Holland, visited this remarkable and picturesque pool, which, by a sounding, was found to be 16 feet deep; but so clear is the water, that the chalk bottom and even the springs in the deepest part could be distinctly seen.

On returning to Watford, the party were hospitably entertained by Mr. and Mrs. Hopkinson.

EXCURSION TO WATFORD.—May 17th, 1879.

Directors—W. Whitaker, F.R.S., and John Hopkinson, F.G.S.

(*Report by* The Directors.)

(*Proc. Vol.* vi. *p.* 191.)

A large party assembled at Bushey Station and proceeded to the Colne Valley Water-works, where Mr. Verini, the Secretary of the Water Company, explained the method of pumping and softening the water.

The members left the water-works for the adjoining chalk-pit, where, after a few fossils had been found, Mr. Whitaker gave an explanation of the section, of which he had published a short description 15 years ago (when probably it was not in such good condition as now), somewhat as follows:—

Ochreous sandy gravel, partly in pipes.
Clay, bluish-grey at top, the rest light-grey, with a layer of a claret-colour at the base.
Chalk with flints.

A bed of clay, the lines of bedding of which were waved, was, he said, deposited very irregularly on the Chalk. The chalk was evidently cut out in a hollow before the clay was deposited, showing a very great interval of time between the deposition of the chalk and of the clay above. Elsewhere such hollows were nearly always caused by the sinking of the overlying beds through the dissolving away of the chalk. The clay could not be older than the Glacial Drift, and he was inclined to class it as Glacial, though Dr. Evans and other geologists believed it to be Post Glacial. The mistake was often made of supposing that all beds termed Glacial were considered by geologists as having been deposited by ice or in an arctic climate, but all that was meant by the term (as expressive of geological age) was that such beds were deposited during the Glacial epoch, in which were intervals of warmer climate as well as cold periods. The bed now seen looked like some beds of brick-earth which elsewhere occurred under Boulder Clay, and it might have been formed in some lake of no very great extent. On the top of this clay might be seen a bed of gravel, but he could not say whether it was a river-gravel or a glacial gravel. If it belonged to the Glacial period, the beds of clay below must also be glacial. Glacial and Post Glacial were,

however, only relative terms, for glacial conditions lasted longer in the North of England than here.

On leaving the chalk-pit the road past Bushey Station was taken, and from an elevated position above Wiggenhall, affording a good view of the valley of the Colne and the hills on either side, Mr. Whitaker pointed out the connection of the features of the country with its geological structure. The range of hills on the edge of which we then stood was, he said, known as the Tertiary escarpment; the term escarpment meaning a ridge along which the beds were cut off. These Tertiary beds had once extended much further over the county, and the escarpment had been at one time beyond its present position, as shown by outliers of the London Clay and of the Reading Beds. The Colne had most probably determined the present line of the escarpment by cutting its way back, but further down-stream it had turned southward, and cut across the beds. The slope on the opposite side of the valley rose gently to a corresponding elevation to that on which we were, and we should find that this ground consisted of gravel-flats of the same character as the one we had just walked over, the river having cut away the beds between.

The valley of the Colne was then crossed, and at the Colney Butts gravel-pits Mr. Whitaker stated that the gravels seen belonged to the Glacial Drift and were probably of marine formation, for in some places, as in Suffolk, marine fossils were found in sandy beds of similar age (older than the Boulder-Clay). The larger stones, perfectly rounded, must have come from the north; the pink quartzites were supposed to have come from the Lickey Hills; and the flint pebbles had come from Tertiary beds, in which they had originally been deposited after the denudation of the Chalk, in which the flints were first formed—a vast quantity of chalk having been denuded to form such extensive gravel-beds.

The Hagden Lane gravel-pits were next visited, and here the irregular surface of the Chalk under the gravel was well seen. Mr. Whitaker remarked that all gravels tended to form nearly level flats wherever there was a large extent of gravel. These gravels were noteworthy as showing no layers of bedding. The very uneven surface of the Chalk seemed to be due to its dissolution by water holding carbonic acid in solution, which percolated through the gravel above. The gravel last seen, where not let down by this dissolution of the chalk, was not more than 20 feet thick, though it occupied large areas.

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EXCURSION TO BERKHAMPSTEAD AND BOURNE END.—Saturday, 21st April, 1883.

Directors—Dr. John Evans, F.R.S., and John Hopkinson, F.G.S.

(*Report by* John Hopkinson.)

(*Proc. Vol.* viii. *p.* 117.)

In Wiltshire there is a River Bourne, which is said to flow in the winter and spring, usually ceasing in the summer and autumn; but the river now under consideration is of a more erratic nature than this, running on the average only about once in from three to seven years. It is known as the Hertfordshire Bourne, and has a parallel in a stream on the opposite side of the Thames valley, known as the Surrey Bourne, which usually flows in the same years as the Hertfordshire stream. To see this Hertfordshire Bourne flowing, and to trace it from its source to its outflow into the River Bulbourne at the hamlet to which it gives the name of Bourne End, was the object of this excursion.

Before, however, proceeding to the valley of the Bourne, the members first visited the ruins of Berkhampstead Castle, close to the station.

The church, dedicated to St. Peter, was next visited under the guidance of the Rev. J. W. Cobb, its principal interest centring in its connection with the poet Cowper, whose father was rector of the parish. From the church Mr. Cobb conducted the party to the rectory, Cowper's birthplace. In the rectory grounds "Cowper's Well" was pointed out, and a large piece of the Hertfordshire conglomerate was inspected.

Continuing to ascend the hill on the south-west of Berkhampstead, Haresfoot Park, the seat of Mr. F. A. Dorrien Smith, was soon reached; and, after walking through the park, a descent was made into the valley of the Bourne, permission having been obtained from Mr. Dorrien Smith to follow the course of the

stream, which flows over his property. The Bourne was encountered where it is crossed by Harratt's End Lane, and where its source was found when it was visited by the Hertfordshire Natural History Society, in 1881. Now, however, it was flowing here in a considerable stream, the field above the lane was in great part submerged, and to find the present source of the river it was necessary to walk about half a mile up the valley by the side of the lake thus temporarily formed, and through some muddy fields.

There is no historical record of the flowing of the Bourne in olden times. Indeed, the existence of this Bourne does not appear to have been placed on record until 1876, when Dr. Evans gave an account of it, recording its having flowed in that year, in 1873, and in 1853, and probably also in 1860 and 1866.* The valley of the Bourne, however, in itself furnishes evidence, in the extensive denudation by which it has been formed, of the existence of a stream, which may or may not have been intermittent, long before historic times.

It was in a field in Buckinghamshire that the party had now assembled, being on the right bank of the stream, in view of its present source and of its course for some distance. Here Dr. Evans explained the geological and meteorological conditions to which the existence of this and other intermittent streams is due, his remarks being as follows :—

"All streams are dependent upon the rainfall; if on hard or impervious soils, directly, for the water in that case at once runs off on the surface; but if on absorbent soils or subsoils, such as chalk, the result is different, for much of the water percolates downwards until it meets with some obstruction. It arrives sooner or later at the surface of a natural subterranean reservoir, for at a certain depth the chalk becomes thoroughly saturated with water. There is a vast amount of water continually in the chalk, and even in the dryest weather there is always water in most chalk-streams, as they are not immediately dependent upon rain. The amount of water flowing from one of these areas is merely a fraction of the amount of rain falling upon it. The yearly rainfall over a period of 50 years in this neighbourhood is 25 or 26 inches. For the 12 years ending 1872 an average of $25\frac{1}{2}$ inches per annum fell, of which about half fell during the summer months (April to September), and the other half during

* "The Hertfordshire Bourne," "Trans. Watford Nat. Hist. Soc.," vol. i. p. 137.

the winter months (October to March). In order to ascertain the amount of water which finds its way more than one or two feet below the surface, Messrs. Dickinson & Co. had a series of gauges constructed, consisting of cast-iron cylinders, 18 inches in diameter, and 3 to 6 feet in length, turned to a knife-edge at the top and sunk to their full depth below the level of the ground in which they are placed, but so that the edge just projects above the ground. Some of these cylinders are filled with the ordinary surface-soil of the neighbourhood, and others with chalk (from the Upper Chalk) in a fragmentary condition, and with sand; grass is growing on the upper surface of the contents of the cylinders, and also on the ground surrounding them; and there are means provided of collecting and measuring the amount of water which finds its way through the cylinders, that is, through three or six feet of soil, chalk, or sand. It is a remarkable thing that, although there may have been a rainfall of 15 or 16 inches in the summer months, not more than one inch finds its way through the ordinary soil, and $1\frac{3}{4}$ through the chalk; while, with an average rainfall for 23 years of 14·17 inches in the six winter months, 6·03 inches went through the three feet of soil, and 8·8 inches through the three feet of chalk. For the same (winter) period for the 12 years ending 1872, the average rainfall was 12·8 inches, of which 5·1 percolated through the soil, and 7·3 through the chalk. With an increase of about two inches in the rainfall in the winter period there was thus an increase of one inch in the quantity which went through three feet of soil, and $1\frac{1}{2}$ in that which went through three feet of chalk. In this way it was found out what is about the proportion of the water which percolates into the soil as compared with that which is carried off by evaporation and vegetation. Some idea of the vast amount of water absorbed from the ground by trees may be gathered from Professor Attfield's paper 'On the Physics and Chemistry of the Sap of Plants.'"*

"After a long period of drought the surface of the underground reservoir falls, becoming very nearly level, in consequence of the water leaving it as springs not being replaced, but after heavy rains the inclination of the surface of the water is again raised. In a well at Studham, miles away from any stream, the level of the water in two successive years has varied as much as 70 feet. When the subterranean reservoirs receive a great

* "Trans. Herts. Nat. Hist. Soc." vol. ii. p. 229.

accession of water by a long-continued rainfall, these bournes, or intermittent streams, make their appearance; but it might happen that the rain which fell in the course of one winter would not be sufficient to raise the surface of the reservoir sufficiently high for a particular stream to flow, and on the other hand it might flow when there had not been any particular heavy rainfall, in consequence of the accumulation of the rain of previous years."

"The Bourne is flowing strongly this year, it flowed last year, and also the year before, thus disproving the old idea that it only flows once in seven years. The plane of permanent saturation is not level, but is inclined towards those places where the water finds its way to the surface of the earth in the form of springs. This plane varies at different times in the year, sometimes being inclined at an angle of 20 feet, and sometimes even at one of 25 feet to the mile, while sometimes the slope is not more than 12 feet to the mile. The rivers flowing past Watford and St. Albans will be found to have an inclination of about 12 feet 6 inches to the mile in the lower portion of their course, and 18 feet 6 inches in the upper portion. This shows what is the amount of impediment to water passing through the chalk in a lateral direction; for, assuming that water could find its way through the chalk at a less inclination than 12 feet 6 inches to the mile, these rivers would cease to flow, or, at all events, the streams would never be seen upon the surface. The whole of the chalk being porous or pervious, unless there were a sufficiently saturated bed beneath the river to hold the water up at an inclination at least equal to that of the river, it would sink into its bed and disappear. The inclination of the subterranean water passing through the chalk must therefore be at least 12 feet 6 inches to the mile in this district."

"In certain years the subterranean water is raised in the body of the hills, and the valley of the Bourne, being cut at right angles or nearly so to the main stream, intersects the general surface of the plane of saturation, and the water appears on the surface of the ground at the bottom of the valley. This theory of intermittent streams being due to the intersection of the plane of saturation, is well illustrated by the fact of the Bourne being sometimes found running in one place, then disappearing, and further on running again, and again disappearing. The plane of saturation being more even than the surface of the ground, where there is an elevation of the surface the water finds its way underground instead of running on the surface. Owing to the large

amount of rain which has fallen in recent years, the Bourne has flowed very frequently during this period, viz., in 1876, 1877, 1881, 1882, and 1883. On some occasions it commences flowing in summer ; this year the flow of the stream will probably cease in June or July."

The course of the Bourne was then followed to Bourne End, where the stream flows into the Bulbourne. In a portion of its course it was found to have taken temporary possession of the road, a *détour* having to be made into the adjoining fields to avoid it, and at Bourne End it was observed to be flowing through the usually dry culvert under the high road in a powerful stream.

The party then proceeded to Boxmoor Station.

References.

Maps.—Same as for Watford (see p. 161).

Books.—Same as for Watford ; with the addition of—J. Hopkinson, The Bourne Valley, Boxmoor, Trans. Herts. Nat. Hist. Soc., vol. i., part 8, p. lviii. 1882.

EXCURSION TO RADLETT.—July 12th, 1884.

Director—John Hopkinson, F.G.S.

(*Report by* The Director.)

(*Proc. Vol.* viii. *p.* 452.)

Starting from Radlett Station, the road leading to Shenley was taken for a short distance, when, by permission of Mr. Thomas Bagnall, Newberries Park was entered. After walking through the grounds adjoining the house a meadow near the park was crossed, and an opening in it, not easily found, revealed the only existing exposure of the Hertfordshire conglomerate. This spot had not before been visited by the Association, and on this occasion the conglomerate was examined under by no means favourable conditions.* The Director gave the following account of the conglomerate in its relation to the strata in which it occurs, the Woolwich and Reading series :—

"We are now standing on the edge of the London Tertiary Basin. We have examined the beds forming the outcrop of the

* On July 19th, 1890, Mr. H. J. Lubbock, of Newberries, had this section especially opened up for the benefit of members of the Association.

Tertiary strata to the south-west at Woodcock Hill near Rickmansworth,* and at Watford Heath and Bushey near Watford,† and to the north-east at Hatfield ‡ and at Hertford.§ All along this line of outcrop we have had the Chalk on the north-west of us and the London Clay on the south-east, while immediately beneath our feet have been the sands, mottled clays, and pebble-beds of the Woolwich and Reading series, reposing on the Chalk and being overlaid by the London Clay, of which we could in some places see only the basement-bed.

"Underlying the Woolwich and Reading Beds, on the opposite side of our Chalk basin, south of London, are the Thanet Sands, but on this edge of the basin they are absent, the Reading Beds here reposing immediately on the Chalk, which appears to have suffered some amount of denudation before their deposition. They are very different in character from their representatives south of London. In the neighbourhood of Woolwich, especially, clays in thin layers predominate throughout, and fossils, which are frequent, show that the beds are of fluviatile or estuarine origin. Here there is usually but one thick bed of mottled clay, with sands above and below, and at the base a bed of flint-pebbles in sand. Fossils are seldom found, and the general character of the beds indicates a marine origin, though partly, at least, littoral.

"It is this shore-deposit that we have now before us, for the Hertfordshire conglomerate is merely a bed of the Woolwich and Reading series—the shingle-bed of flint-pebbles consolidated by the infiltration of silica. At Watford there is a shingle-bed 15 feet thick, the black flint-pebbles being in a matrix of ochreous clayey sand, but not consolidated; and in fact it is only at this spot that a shingle-bed can now be seen *in situ* in the form of a conglomerate, or, as it is sometimes called, 'plum-pudding-stone.' Blocks of this conglomerate occur, however, here and there, over a considerable portion of Hertfordshire, and they have also been seen in Essex. We know that the Reading Beds once extended over the greater portion of Hertfordshire, by the outliers which are seen at various places, and it seems more probable that the blocks we meet with are relics of these beds, of which the looser portions have been carried away by denudation, than that they

* "Proc. Geol. Assoc.," vol. vii. p. 397.
† *Ib.*, vol. ii. p. 43; vol. iii. p. 65; vol. iv. p. 284; vol. vi. p. 191.
‡ *Ib.*, vol. iii. p. 240; vol. iv. p. 518.
§ *Ib.*, vol. v. p. 519.

have been transported in a northerly direction from the neighbourhood of Radlett. It is probable that the land over which the rivers flowed which deposited the clays, sands, and pebbles of the Woolwich and Reading series was to the south of the London and Hampshire Tertiary basin, where the English Channel now is, and on this supposition we should expect to see the beds to the north more marine in character than the more southerly portion of the series. From the very variable character of the whole of this series it may be inferred that in no locality where it occurs was it, or any portion of it, a deep-sea deposit. Littoral conditions may have prevailed over at least a considerable portion of Hertfordshire, so that there is no improbability in the shingle-bed having at one time been of considerable extent, and throughout this extent it may anywhere have been consolidated into a conglomerate.

"The conglomerate is here seen to be split up into blocks, and the durability of the siliceous cement is evidenced by the splitting of the pebbles. In some places the pebbles have become so soft that they can be cut with a knife, while the matrix preserves its hardness. Another point of interest is that here and there the surface of the conglomerate is seen to be smooth and rounded, as if it had been subjected to the action of ice. It is the only rock we have anywhere in this neighbourhood, and probably in our whole Tertiary basin, which is sufficiently durable to show any trace of glacial action."

A careful examination of the conglomerate was then made in different parts of the pit, and pebbles here and there were freely subjected to the action of pen-knives, a few being found which could be cut into. The splitting up of the conglomerate was observed, and its surface was seen to be in some places evidently *moutonnée*. The beautifully white, fine sand seen reposing upon an unconsolidated portion of the pebble-bed also attracted attention.

The road leading to Boreham Wood was then taken for a short distance, and, turning off it towards Letchmoor Heath, a stream flowing out of Elstree reservoir into the River Colne was crossed. The bed of this stream is frequently dry, and there was not much water in it, but the proximity of the underground reservoir, the plane of permanent saturation in the Chalk, was evident from a stream of water running down the road, which was not merely surface-drainage from the recent rain, its source being beneath the surface.

The route was now past Kendall Hall, and then past Kendall Pound, between which place and Battler's Green the principal "swallow-holes" in the district are to be seen, there being others near Letchmoor Heath and Bushey. On arriving at the Battler's Green swallow-holes no water was to be seen. There having been a long period of dry weather the recent rainfall had been speedily absorbed; but that sometimes a large quantity of water would be seen to disappear was evident from the amount of solid matter which had been carried away.

When swallow-holes occur in the bed of a stream the water may sometimes be seen to disappear entirely in dry seasons, while when a large amount of water flows they may take part of it only and the stream may flow on merely diminished in volume. In the carrier which conveys the water from the Elstree Reservoir to the River Brent there are some swallow-holes which have to be plugged when the water is discharged from the reservoir to prevent the waste of the greater part if not the entire volume of the water. This carrier must there be above the plane of permanent saturation of the Chalk, but most of our chalk-streams flow at the level of permanent saturation.

After walking a short distance across the fields the party separated at Battler's Green, some walking to Radlett Station, and others driving to Watford.

[An excursion to *Shenley* took place on July 19th, 1890, Upfield Green being Director. Shenley is near Radlett, Herts.]

EXCURSION TO HATFIELD.—June 28th, 1873.

Director—J. Logan Lobley, F.G.S.

(*Proc. Vol.* iii. *p.* 240.)

Though little visited as a locality of geological interest, the neighbourhood of Hatfield presents sections both of the older and of the newer Tertiaries of considerable importance. Situated on the northern edge of the London Tertiary Basin, Hatfield is an advantageous point of departure for a geologist who wishes to trace the junction of the Secondary and Tertiary Beds. To enable the Members of the Association to traverse this line, and to inspect the principal section, the Marquis of Salisbury courteously threw open Hatfield Park.

On reaching the extreme eastern limits of Hatfield Park the party entered an extensive excavation, in which are seen all the

beds occurring in this locality between the London Clay and the Chalk, which forms the bottom of the excavation, with the high level Post-Pliocene gravel capping the whole.

Mr. Whitaker, in "The Geology of the London Basin," p. 226, gives the following details of this section :—

		Feet.
	Gravel composed of various sized pebbles of flints, white and pink quartz, quartz rock, and some other rocks, and subangular flints, in coarse whitish sand, in parts as much as	6
	Stiff brown clay, more sandy towards the base	20
London Clay. Basement Bed.	Brown loam with green grains	
	Thin bed of brown clay	
	Olive green and dull brown sand	
	Dull brown sand with green grains and perished shells	about 7
	Brown loam with small nodules of stone and perished shells	
	Thin bed of flint pebbles, mostly small	
Reading Beds.	White and light-coloured sand, with layers of grey laminated clay ; at parts some very small pieces of ironstone, and here and there a flint pebble ; for the most part regularly bedded, but a little false bedding in the lower part	about 23
	Bottom Bed—Flint pebbles and subangular flints ; very dark green (almost black) outside, in sand ; the upper part ironshot, the middle grey and greenish yellow, the base ironshot ; greatest thickness	about 2
	Chalk with flints. Junction even and with a dip about S.E.	

It will be noticed that the Thanet Sands are not present here, and that the beds immediately below the London Clay Basement Bed have the character of those near Reading rather than of those in the neighbourhood of Woolwich, while the mottled clay is entirely wanting. The sands overlying the Chalk might be mistaken for the Thanet Sands, but the thinning out of those deposits considerably to the south of this locality, and the evidence of other sections in the district, leave no room for doubt as to the age of these beds. A multitude of sand-martins find a home in the sands, which are quite honeycombed by these industrious excavators. The section having been explained, the party left the spot, and ascended to the higher level, where a brick-pit exposes a continuation of the section, and shows the High Level Gravels capping the London Clay, and thence proceeded, by a north-western route for about three miles, to a cutting on the Great Northern Railway, where a section nearly half a mile in length exposes the Middle Glacial Sands and Gravels, with a thin overlying sheet of Boulder Clay forming the subsoil of the land. The railway to Hatfield was then traversed, and the sections of the Glacial Beds

along this part of the line were examined. On arriving at Hatfield the party took train for London.

[A second excursion to *Hatfield* was made on May 13th, 1876, the director being John Hopkinson. There is a brief report of this excursion in Proc. vol. iv. p. 518, Mr. Hopkinson referring the reader to the above account of the geology of the district. The following details, however, are from Mr. Hopkinson's report.]

Permission to see over Hatfield House, and to visit the Hatfield Park Kiln, had been kindly granted by the Marquis of Salisbury.

The house, which was first visited, is necessarily more of historical than geological interest. It is built on the site of the palace of Bishop Morton, which was erected about the end of the fifteenth century, and of which a fragment still remains; and on its site again, from the commencement of the twelfth century, an episcopal residence had existed. The present mansion was commenced in 1607, and the materials used in its construction by its builder and architect, Robert Cecil, Earl of Salisbury, consisted chiefly of Caen stone, with stone from Tattenhall, Worksop, and the Northamptonshire quarries, and bricks and flints from the old palace which had fallen into decay.

After spending a considerable time in the house and grounds, the party proceeded across the park to the brickfields, noticing on the way Queen Elizabeth's favourite oak, under which she was sitting when the news was brought to her that she was Queen of of England.

[Potter's Bar, Potterell's Park, and Hatfield were visited on April 19th, 1890, the Directors being Upfield Green and Dr. Morison.

An excursion to *Welwyn* took place on May 15th, 1886, Director, John Hopkinson. A report, by the Director, appears in the Proceedings (vol. ix. p. 534).]

EXCURSION TO HERTFORD AND WARE.

SATURDAY, 22ND JUNE, 1878.

Directors—Prof. JOHN MORRIS, F.G.S., and JOHN HOPKINSON, F.G.S.

(*Report by* Mr. HOPKINSON.)

(*Proc. Vol.* v. *p.* 519.)

ON this occasion members met at Hertford Station at half-past ten.

The first place visited was Hertford Castle, near which there are

still standing, completely overgrown with ivy, the ruins of a much older structure, once an important fortress, supposed to have been built by King Alfred.

From the Castle the route lay through the churchyard, famed for its fine avenue of chestnuts, 200 years old, and thence, by permission, through Ball's Park, the seat of the Marquis Townshend, to Mr. Lines' brickfield, between Rush Green and Little Amwell, the first point of geological interest. Before, however, the brickfields were visited, a chalk-pit near afforded Professor Morris the text for an interesting address, in the course of which he showed that the flints immediately above the Chalk were of a different colour from those in the Chalk, some chemical change having given them a green coating. The presence of this bed of green-coated flints, known to borers as the Bull's Head Bed, was a proof that we had the true surface of the Chalk, the bed forming the basement of the Tertiary Series. Another interesting point connected with the Chalk here, was that it contained very little silex, for it had segregated in the form of flints; while, in the Chalk without flints, the silex was probably distributed through the mass. Mr. Lines stated that in the bed above-mentioned sharks' teeth and oyster shells (*Ostrea Bellovacina*) were frequently found.

Various sections exposed in the brickfields were then examined, Professor Morris explaining the relative position of the different beds, and their relations to each other, and to beds elsewhere which are here wanting. In this district he said that we had the lowest portion of the Tertiary Series seen north of London, but not the lowest known in the London area, for while the Thanet Sands were being deposited south of the Thames, the Chalk here was nearer the surface, not allowing of their deposition. The Woolwich and Reading Beds also were only partially represented. They consisted of alternations of sands and clays, and showed a very different set of conditions from that on the south of London, where there were 30 or 40 feet of ash-coloured sands. Here there were no freshwater shells, though these beds were contemporaneous with the freshwater beds found at Lewisham, &c., which contained a great number of shells. While south of London there were freshwater and estuarine conditions, in the north and west the deposits were entirely marine.

Other beds which form a passage between the Woolwich and Reading series and the London Clay were next examined, and Professor Morris stated that they represented an important change

of conditions. Their black flint-pebbles were interesting as being derived from unworn flints perfectly rolled on some sea-shore, and, after being rounded, spread over the surface, where they were now found. These higher beds, the Basement-bed of the London Clay, evidenced a great depression of a very large area, extending between Marlborough, Hungerford and Harwich.

From the brickfields the route lay across the fields to Little Amwell, near Hertford Heath, the highest point visited during the day, where excavations are in progress for a reservoir to supply the village with water. Here the Professor continued his lecture on the geology of the neighbourhood. Few districts were, he said, so interesting geologically as this and those adjacent which had been partly worked out by Professor Hughes. Other heights of the same level were seen around, and these elevations were the remnants of a surface of uniform height which had been cut into deeply by denudation, the present river-valleys being formed and gravel deposited. The gravel beds of the higher levels might be seen to contain pebbles from a great distance—Wales, Cumberland and Scotland. They were the high-level gravels of Professor Hughes. It was improbable that they were here first formed in place as pebbles, some at least being pebbles of far older age. After the pebbles were deposited an emergence took place, and the land became scooped out, and great valleys were formed. During a period of submergence the Glacial or Boulder-clay materials were brought from the north; and here the Boulder-clay was seen to have mixed up the gravel of high-levels, and brought with it other materials. After this period a partial emergence took place, and after this emergence rain and rivers gave the present contour to the country, forming the third or River-gravel period, so that the district now presents beds of High-level gravel, Boulder-clay and gravel, and Low-level gravel.

From Little Amwell the route lay through the Walnut-tree Walk, then the party passed through Amwell Bury, by permission of the Misses Bevan, and came upon the high road near the Amwell Hill lime-kilns, where a few fossils were found, and some fine examples of vertical "pipes," exposed at the sides of an extensive chalk-pit, were specially noticed.

Climbing one of the sides of the pit, Amwell Magna was almost immediately reached, and the well-known spring which rises here from the Chalk, affording the New River Company a copious supply of water, was visited. It is evidently a subterranean stream, flowing for some distance in the chalk towards the

River Lea, and finding its way to the surface close to the river under which it flows.

The next point of interest was near the New River Head, on the road from Ware to Hertford. Here the Diamond Rock Boring Company were boring for an additional supply of water for the New River Company. On arriving at the scene of operations, the party, by permission of the New River Company and of Colonel Beaumont, had the opportunity of becoming acquainted with the various methods of working adopted.

Evening was drawing near, and the party had to hasten from the boring to Ware Priory, the residence of Dr. J. Gwyn-Jeffreys, F.R.S., who had invited the members to tea.

The party then left the Priory for Ware station.

[Another excursion to *Hertford* and *Ware* took place on May 16th, 1885, Mr. Hopkinson being again director. A report of it may be seen in Proc., vol. ix., No. 4, p. 182.]

References.

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T. McK. Hughes, The Two Plains of Hertfordshire and their Gravels. Quart. Journ. Geol. Soc., vol. xxiv. pp. 284-286.

S. V. Wood, On the Pebble-Beds of Middlesex, Essex and Herts. Quart Journ. Geol. Soc., vol. xxiv. p. 468.

[The Trans. Herts. Nat. Hist. Soc. contains numerous papers relating especially to the district.]

ESSEX.

EXCURSION TO ILFORD, AND VISIT TO SIR ANTONIO BRADY'S MUSEUM.—June 17th, 1871.

Directors—Dr. Henry Woodward, F.R.S., and Sir Antonio Brady.

(*Proc. Vol.* ii. *p.* 273.)

The members proceeded by the Great Eastern Railway to Ilford, from which place a walk of less than a mile brought the party to

the Uphall Brick-field, where is seen one of the exposures of the Mammaliferous Brick-earth of the Thames Valley, which have rendered this locality famous for the remains of the larger Mammalia of the Pleistocene period.

FIG. 67.—SECTION AT UPHALL PIT, ILFORD, SOUTH SIDE.

[Reprinted from the Quart. Journ. Geol. Soc., vol. xxiii.]

6. Surface-soil, from 1-3 feet.
5. Irregularly stratified Brick-earth and Gravel, 6 feet.
4. Irregular layer of Flint-Gravel, 1 foot.
3. Fine red and grey Sandy Loam, 4 feet.
2. Fine Sands and chocolate-coloured Brick-earth, 6 feet.
1. Yellow Sand and Gravel.

Dr. Woodward remarked that though elephant remains have been abundantly obtained from both Ilford and Grays, yet there is a remarkable difference in the distribution of the species ; for while *Elephas primigenius* is the common species at Ilford, it is very rare at Grays, where *Elephas antiquus* is found taking its place. In addition to *Elephas primigenius*, the beds at Ilford yield many other species of Mammalia (*see* Woodward and Sherborn, Cat. Brit. Foss. Vert., 1890.) These have been taken chiefly from the Brick-earth associated with and covering in some places the great sheet of the Thames Valley Gravels, and having a thickness of from five to eight feet. The Brick-earth extends over considerable areas in the Thames Valley, and is especially well seen about Wanstead, West Drayton, and Tottenham, but it is by no means rich in organic remains. The lower beds at Ilford, in common with the Grays and the Crayford deposits, yield abundantly *Corbicula (Cyrena) fluminalis*. The London Road pits were then visited, and the sections at this place, very similar to the Uphall exposures, were examined.

The party then inspected the magnificent Collection of Mammalian Remains, collected by Sir A. Brady [now in the Natural History Museum], which were derived almost exclusively from the Uphall and London Road pits of Ilford. The teeth of perhaps one hundred elephants are in this collection, and attest the former abundance of these great pachyderms in the Thames

Valley. Sir Antonio Brady, after pointing out the more important specimens in his collection, gave his visitors a very interesting account of the manner in which the large specimens were exhumed. While *in situ*, the bones are so fragile that it is necessary to take the greatest possible care lest they fall to pieces while being removed, and in some cases it is requisite to remove with the bones large quantities of the earth in which they are imbedded. A fine collection of stone implements and antiquities was also inspected by the members.

[*Grays Thurrock* has been the scene of many excursions. The first took place on April 21st, 1866, the second on May 23rd, 1868: both during the cessation of the issue of Proceedings. The next visit was on April 23rd, 1870, and a brief report appears in Proc. vol. ii. p. 29. A fourth is here given.]

EXCURSION TO GRAYS, ESSEX.—May 20th, 1871.

Director—Rev. T. Wiltshire, M.A.

(*Report by* M. Hawkins Johnson.)

(*Proc. Vol.* ii. *p.* 245.)

The country from Fenchurch Street to Grays by rail is not, to a geological eye, the dreary flat it may appear to many. The mind reverts at once to the time when the Romans had not yet built the river-wall, which for so many ages has protected the marshes from daily overflow; when peaty swamps and muddy pools overgrown with reeds were by slight variations in the level of the land sometimes a few inches above, and sometimes a few inches below, the waters of the estuary.

The curious mass of Chalk at Purfleet, standing up in isolation, with its cap of Thanet Sand, looking like the remnant of some old castle, and the cliffs exhibiting a similar section at Greenhithe, on the other side of the river, are both interesting.

The party proceeded to Mr. Meeson's chalk-pit, a very extensive excavation, exhibiting a beautiful section of the Upper Chalk, capped by the Thanet Sands, overlying which is the gravelly Brick-earth deposit of Post-Glacial age.

The Chalk here contains beds of nodular flints, distributed with such regularity, that in section they show out as long, black, broken lines; also flint nodules irregularly scattered throughout the mass. Sheets of tabular flint were seen parallel to the lines

of stratification; also some sheets of tabular flint cutting the lines of stratification obliquely; these latter mostly present the appearance of being double, that is, composed of two layers, and are well worth careful attention, as their origin is difficult to account for. The green-coated flints, known as the "Bull Head Bed," were well seen in their usual position, between the Chalk and Thanet Sands, and many flint casts of echinoderms, in a good state of preservation, were found.

The fossils obtained from the Chalk were,—a large fish much crushed, not identified; teeth of *Otodus appendiculatus* and *Ptychodus;* shells of *Plagiostoma spinosum* and *Inoceramus; Terebratula carnea; Diadema*, also separate plates of the same, called by the quarrymen "nipple rings," from the projecting processes for articulation with the spines, of which many were also found. The other common echinoderms were tolerably plentiful, such as *Echinocorys scutatus*, *Micraster cor-anguinum*, and *Galerites albogalerus;* the coral *Parasmilia* and several Bryozoa were also noted.

Large masses of flint, coloured brown by oxide of iron, were found above the Bull Head Bed, indicating great denudation of the Chalk before the deposition of the overlying sand, and representing probably a great interval of time; a mass of Sarsen-stone was also seen, no doubt an indurated portion of a sandy bed in the Woolwich series, which originally extended over this area.

The junction of the Chalk with the overlying layers is full of interest, and suggested innumerable speculations to account for the peculiar outline presented. Generally the irregular portions of chalk above a certain plane contain pebbles and clay. A bed of pebbles in the gravel bed where it passes over a portion of the Chalk, in which there is one of those funnel-shaped excavations filled with sand known as "sand-pipes," is much bent downwards at this point; it has, in fact, sunk in, showing that the formation of the sand-pipe took place long after the deposition of the beds above, which of course were originally level, or nearly so.

Attention was now directed to the Brick-earth beds, a little lower down the river, and known as Pearson's pits. The bed where the Mammalian remains were discovered is in that part entirely removed, and the surface planted with potatoes, but low down in the section exposed, two or three thin sandy beds intercalated with marly clay were found, abounding in fresh-water shells, the most abundant being *Corbicula fluminalis*, a shell now extinct in

FIG. 68.—SECTION AT MR. PEARSON'S PIT, GRAYS THURROCK.

[From the Quart. Journ. Geol. Soc., vol. xxiii.]

7. Surface-soil, 3 feet.
6. "Trail," from 3-4 feet.
5. False-bedded Sands, and Lenticular Gravel-beds, 10 feet.
4. Grey Laminated Clay, with seam of Gravel, 4 feet.
3. Lenticular mass of Shells.
2. Laminated grey and reddish Clays, interstratified with Sand and Gravel, 14 feet.
1. Sand and Gravel, 10 feet.

Chalk.

FIG. 69.—SECTION AT GRAYS, ESSEX.

[From the Quart. Journ. Geol. Soc., vol. xxv.]

e. Covering Gravel.

d. False-bedded Muds, 18 feet.

d'. 4 feet Pebble-bed, with Shells.

c'. Elephant-bed.

c. *Cyrena*-bed, 1 foot.

c''. Mottled Clays, with *Cypris* living now in Thames; plants; 10 feet.

this country, but still living in the Nile, a fact which points to the existence of a warmer climate at the time of the deposition of these beds. *Bythinia tentaculata*, *Valvata piscinalis*, and other still existing shells were found; and in another bed, about three feet higher in the series, *Unio littoralis* abounded; this shell is also extinct in this country, but lives in the Loire; and as this latter bed is more recent than the Cyrena beds, and its shells do not require so warm a climate, the alteration of the temperature may probably have gone on gradually in the same direction from the earlier epoch to the present day.

The false-bedding of the sands in this pit is well worthy of observation.

[*Grays* was again visited on May 16th, 1874, and on April 21st, 1877. Both these excursions are briefly chronicled, Proc. vol. iv. p. 123 and vol. v. p. 125.]

EXCURSION TO GRAYS.—Saturday, May 14th, 1881.

Directors—Professor J. Morris, F.G.S., and Henry Walker, F.G.S.

(*Report by* Henry Walker.)

(*Proc. Vol.* vii. *p.* 148.)

Alighting at Grays Thurrock, the party were conducted along the high road leading to Stifford. Here was well seen the wide extent of the three southern chalk-pits at Grays. Attention was called to the flooded condition of the Eastern Pit, which was explained subsequently. On descending to the Central Pit, one of the numerous Greywethers, or Sarsen-stones, was found lying on the unworked surface of the Chalk where the Thanet Sand had been breached. Professor Morris noticed its partially-rounded condition, which characterises Greywethers. Although the Woolwich Beds were wanting here, these were found about a mile further inland, and he suggested a careful search at Stifford, in Essex, where a solitary shell had been found in these beds north of the Thames. This was now in the Woodwardian Museum at Cambridge.

The abandoned Western Pit, in which the South Essex Water Company obtain their supply, was next visited, and Mr. Walker gave an account of the hydro-geology of the district. In the year 1861, the Chalk had been worked to the level of the spring in this pit over an area of about 60 acres, when attempts to go deeper led to the discovery of an abundant supply of pure water. The

amount passing over the gauge every twenty-four hours was found to exceed 2,100,000 gallons, and yet it was necessary, with five engines at work, to brick up fissures so as to keep the water down. The present supply for consumption is 650,000 gallons daily, and nearly an equal amount is pumped to waste to avert inundation. No deep wells are needed, the water being found at the surface; the engine-house floor is only 17 feet above ordnance datum, and the water in the well varies from that datum to eight feet below it. To account for so large a volume of water in a district where the superficial pervious beds do not exceed ten miles in area, Prestwich extends the receiving ground to the Kentish Chalk, considering that the intervening Thames would not necessarily interrupt all the springs.*

After an inspection of the engine-house the members were conducted to the high ground separating the Eastern from the Western Pits, whence the physical structure of the surrounding country can be studied. Northward, Langdon Hill with its capping of Bagshot Sand and Pebbles (388 feet), is the most conspicuous feature. Southward, over the Thames, owing to the rise in the beds towards the Weald, a wholly different aspect is revealed. The absence of the Upper Tertiaries, the wide exposure of the Kentish Chalk, its dip-slope with wooded outliers of the Lower Tertiaries, as at Swanscombe and Cobham Mount, were successively pointed out and described by Professor Morris.

[*Grays* was also visited on June 16th, 1883, and on May 9th, 1885, the object of the visit on each occasion being an inspection, not of the Chalk-pits, but of the Deneholes of Hangman's Wood, an account of which follows.]

EXCURSION TO THE DENEHOLES OF HANGMAN'S WOOD, NEAR GRAYS, ESSEX.—June 16th, 1883.

Directors—T. V. Holmes, F.G.S., and H. Walker, F.G.S.

(Report by T. V. Holmes.)

(*Proc. Vol.* viii. *p.* 182.)

Hangman's Wood is about a mile and a half N.E. of Grays Thurrock Railway Station. The Deneholes there are said to be seventy in number, and like those at Stankey Wood, Bexley, are concentrated in a very small space. Only five shafts (admitting to six pits) are now open.

* "The Water Springs in Grays." Privately printed, 1860.

These Hangman's Wood pits are in the same strata as those of Stankey and Cavey Spring, Bexley. The surface is composed of gravel equivalent to that of Dartford Heath, which overlies Thanet Sand. Sections in this gravel are observable here and there between Grays and Hangman's Wood; but the well-known Chalk pits of Grays lie mainly north-west, not north-east, of that place. Hangman's Wood, however, is within a mile of the easterly edge of the Chalk area, and is on a plateau (about 90 feet above Ordnance Datum at Hangman's Wood) commanding fine views of the river from its southern edge. The Deneholes are rather deeper than those of Stankey or Cavey Spring, averaging about 80 feet. The visitors descended the pit marked as No. 3 (Essex Naturalist, No. 12, 1887), a six-chambered denehole of the double-trefoil plan so common as a stage in their evolution. The geological section afforded by No. 3 is given below. Sections of other pit-shafts would vary from it merely as regards the thickness of the chalk roof of the chambers, or the height of the chambers themselves. Thus one denehole may have a chalk roof 6 feet thick, and its chambers a height of 16 feet; another a chalk roof of 2 feet 6 inches and a height of 18 feet.

Section of No. 3.		Ft.	In.
Gravel (Dartford Heath Terrace) about .		6	6
Thanet Sand		51	0
Chalk { roof . 4ft. 6in. } { height. 18ft. 0in. } . .		22	6
		80	0

The greatest length, in a straight line, attained in No. 3 is 70 feet.

Means of descent of a somewhat ruder character than those employed at No. 3 enabled a few persons to descend shaft No. 5, which is situated between fifty and sixty yards N.N.E., or thereabouts, of No. 3. The pit at the bottom of the shaft was found to be of the double-trefoil shape, and its size about equal to that of No. 3. The band of black flint, so conspicuous in No. 3, at a height of 5 feet to 6 feet above the floor, was equally noticeable in No. 5; but the most interesting fact in connection with this pit was the existence of an aperture which enabled its visitors to enter two of the chambers of an adjacent denehole. The shaft of this last pit (No. 6) had fallen in, and, but for the break in the Chalk partition between it and No. 5, it could not have been entered. It seems probable that this break is of

ancient date, and the result of accident. The two chambers in a straight line with the openings at the base of the shaft of No. 5, appeared to be nearly in a straight line with the chamber of No. 6, into which admission was obtained through the broken partition. Denehole chambers always end with a rounded, apse-like termination, and this partition appeared to have been accidentally broken through after the ends of the two contiguous chambers had been rounded off.

In a well adjoining Gravel-pit Barn, close to Hangman's Wood, the water-level was found to be 71 feet below the surface on June 15th. As the surface at this spot is not more than from 12 feet to 15 feet below that of Hangman's Wood it would appear that the floors of the deneholes there are very slightly above the permanent water-level in the Chalk of this district.

[The visit to the *Hangman's Wood Deneholes* in 1885 took place after the Denehole Exploration of the Essex Field Club had been carried on there in the previous autumn for a month, under the direction of the leaders of the excursion, T. V. Holmes, Pres. E.F.C., and W. Cole, Hon. Sec. Consequently, on the second occasion, the visitors were enabled to enter twelve distinct pits after descending a single shaft. A report of this excursion appears in Proc., vol. ix. p. 179. It may be useful to add that a report of the Denehole Exploration, fully illustrated, was published in December, 1887, by the Essex Field Club, and may be had of the Hon. Sec., Mr. W. Cole, 8, Knighton Villas, Buckhurst Hill, Essex. (Price 2*s.*)]

Laindon, or Langdon, Hill.

[An excursion to *Laindon Hill*, by the new railway from Barking to Pitsea, took place on June 9th, 1888. The Directors were W. Whitaker and Walter Crouch. *See* Proc., vol. x. p. 489.]

References.

Maps.—Ordnance Survey. Geological. Sheet 1, S.E., S.W. 3*s.* each.

New Ordnance Survey. Sheets 257, 271. 1*s.* each.

Books.—W. Whitaker, Geology of London, 8vo, London (Geol. Surv.). 1889. 11*s.* [For literature.]

B. B. Woodward, On the Pleistocene (non-marine) Mollusca of the London District, Proc. Geol. Assoc., vol. xi., 1890, p. 335.

Publications of the Essex Field Club, referred to above.

EXCURSION TO TILBURY DOCKS.—May 17th, 1884.

Director—T. V. Holmes, F.G.S.

(*Report by* The Director.)

(*Proc. Vol.* viii. *p.* 392.)

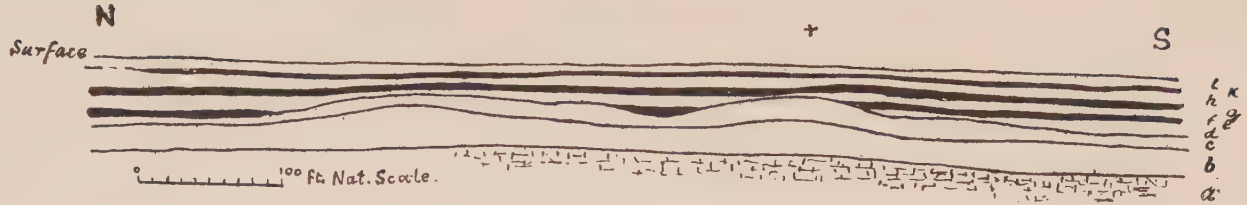
The party entered the dock excavations, the plan of which was explained by Mr. J. B. Pinker.

The sections seen consisted of bluish clay, interbedded with peaty bands, above sand and gravel. The various beds vary considerably in thickness, and undulate slightly. Only two peaty beds were visible. We were informed by Mr. Pinker, however, that a third peaty band has been found here and there, resting directly on the sand or gravel, in the numerous trial borings made within the dock area. Mr. Whitaker sent the details of two borings made between Tilbury Docks and Fort, one of which shows the presence of this lowest peaty band. It was also met with in the new well at Tilbury Fort. The sections of the Tilbury Fort Wells are given by Whitaker in his paper on "Some Essex Wells" (Trans. E.F.C., vol. iv. p. 149), and details of the borings in the Dock area are given by the same author in his Geol. London (1889), vol. ii. pp. 285-9.

The lower of the two peaty beds visible in the dock excavations was examined, and found to contain the remains of reeds, horse-tails, heather, and other plants, reeds decidedly predominating. An offensive smell of sulphuretted hydrogen proceeded from the vegetable remains in this peat bed, though 20 feet or more below the surface, and dating from a period long before the Roman occupation of Britain. The preservation of these plant-remains in this slightly decomposed state is of course due to the thick clay beds both above and below, which have prevented total decay. And though in this case the influence of the clay may be considered advantageous, we also get therein a striking illustration of the disadvantages of clay as a site for cemeteries. The trunk of a fine willow tree had been found about 40 feet below the surface.

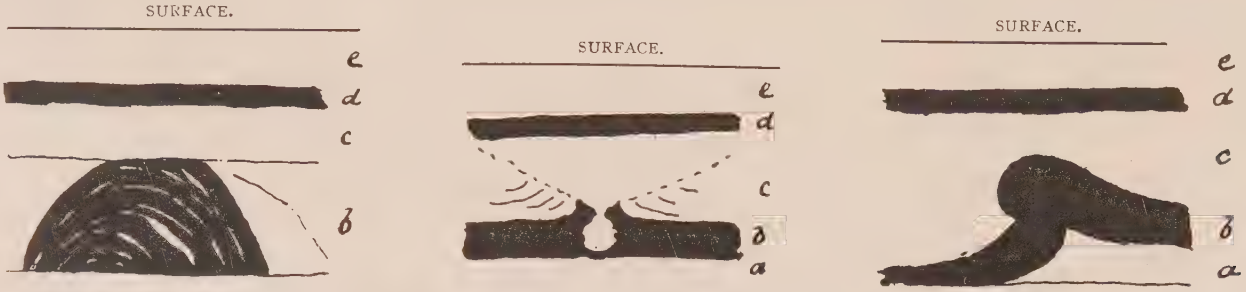
From a slightly elevated ledge of clay the Director made some remarks on the sections around, concluding with a few words on the age of the human skeleton discovered during the progress of the excavations. The blue clay, he said, evidently consists of inundation-mud deposited during floods, the peaty bands interbedded with it marking the position of former land surfaces, the

FIG. 70.—SECTION IN DOCK EXCAVATION, TILBURY.



a. Chalk. *b*. Gravel. *c*. Sand. *d*. Tidal Clay. *e*. Peat. *f*. Tidal Clay. *k*. Peat (Roman Surface). *l*. Tidal Clay.
\+ Place where the human bones lay in sand. [Spurrell, after Whitaker.]

FIGS. 71, 72, AND 73.—THREE FIGURES REPRESENTING THE PECULIAR DISTORTIONS OF THE PEAT AT TILBURY.



The lettering is the same in all the figures, *b* being the main Peat. [Spurrell.]

plants composing them having evidently lived *in situ*, at, or slightly above, high-water mark. Consequently the present position of these peaty bands indicates a subsidence in this area. But these remarks do not necessarily apply to the lowest (invisible) peaty bed, which rests directly on the sand or gravel. For the sand and gravel having been brought down and deposited in the channel of the river, it is not unlikely that peaty matter resting directly upon it may consist of vegetable remains that have been carried down in the stream and deposited where the current was sluggish, as it is sure to be on one side of an island in a river. Capt. Hall, quoted by Lyell (Principles Geology, ed. 11, i. p. 440), remarks of the islands of the Mississippi, that the interval between them and the shore is often found to be "filled up by myriads of logs cemented together by mud and rubbish." And of course a peaty bed so formed offers no evidence of subsidence.

As to the skeleton found at a depth of 32 feet, resting on the sand, Mr. Pinker pointed out the spot at which it was discovered, in the tidal basin, or part of the Docks nearest the river. This skeleton formed the subject of a paper by Sir Richard Owen (Proc. Roy. Soc., vol. xxxvi., 1883, p. 136, and 8vo, *London*, 1884, 32 pp., pls. and section), and has been persistently called "palæolithic" in the newspaper reports. It seemed necessary, therefore, to point out that, though prehistoric, it by no means deserves to be styled palæolithic. But for the embankment of the Thames in Roman times, the strata in which it was found would now be receiving additions whenever an unusually high tide occurred.* The remains probably floated down the stream, and were deposited somewhere near the shore, where the current was sluggish. The Thames at Gravesend never flowed southward of its present course, though the breadth of alluvium north of Tilbury Docks and Fort shows that its channel must once have been a mile and a-half north of that now existing. The river appears at this point, therefore, to have been steadily cutting its way southward during the formation of its present alluvial flat. Consequently, as the skeleton was discovered only from one hundred to two hundred yards north of the Thames (as it now flows), its age need not be very much greater than that of the embankment confining the stream, though it must exceed it to

* The present level of the marsh at the Docks is—we learn from Mr. Pinker—from 7 ft. to 8 ft. below high-water mark. But this shrinking is the result of the embankment and of subsequent drainage.

some extent. The skeleton, therefore, is clearly prehistoric; but the gross exaggeration of age implied by the term "palæolithic" is equally obvious. Flint implements have been found at Crayford in an old river deposit that must have been formed when the Thames flowed at a height of 50 feet above its present level, and they have been discovered at many other places in its valley at heights of from 20 feet to 50 feet above the present stream. Now it is evident that to class together under the name palæolithic human remains or implements found in these older alluvial beds and those of the recent alluvium of Tilbury marshes is to ignore the great interval of time indicated by the change in the physical geography of the district, and to group together the relics of widely separated eras.

References.

Maps.—Same as to Grays (see p. 181).

Books.—F. C. J. Spurrell, On the Estuary of the Thames and its Alluvium, Proc. Geol. Assoc., vol. xi., pp. 210-230. 1889.

[There was an excursion to *Brentwood* on May 25th, 1889, the Directors being R. S. Herries, H. W. Monckton, and H. B. Woodward. See Proc. vol. xi. p. lxii.]

EXCURSION TO WALTON-ON-THE-NAZE.

July 8th, 1872.

Director—J. Logan Lobley, F.G.S.

(*Proc. Vol.* iii. *p.* 122.)

The Red Crag is well exposed on the coast of Essex, in the low cliffs north of Walton-on-the-Naze, where it occurs as an outlier from the main mass.

The town of Walton-on-the-Naze is on the London Clay, which here forms low elevations, and is well exposed in the cliffs immediately to the south. Further southwards the London Clay is covered by deposits to which Searles Wood gives the name of Post Glacial Valley Beds.

Turning northwards, leaving the town, and walking along the shore, we soon reach a point opposite to a cliff a portion of the face of which has an orange-red colour. This is the section of the Red Crag so well known to collectors as a rich mine of fossils. Ap-

proaching the cliff more closely we find the Crag to be, not as its name would seem to imply, a rough hard rock, but a mass of loose comminuted shells with gravel and sand, easily disintegrated and affording very slight resistance to wearing agencies, whether sub-aerial or marine. Even the operations of the fossil collector, if not carefully conducted, may bring down large masses of material, and so destroy some of the land above. The proprietor of the cliff had granted permission to the party to examine the section and collect fossils.

The London Clay forms the base of the cliff, and immediately underlies the Red Crag, which is seen forming the middle of the section. Overlying the Red Crag occur beds of the Chillesford Series, and these again are capped by the Middle Glacial gravel of Searles Wood, which forms the top of the cliff, at an elevation of about 50 feet above the sea-level. The Red Crag generally varies from three to twenty feet in thickness, and is characterised by a remarkable oblique bedded structure, especially well seen at Bawdsey Cliff, as pointed out by Mr. Wood, in his "Supplement to the Crag Mollusca" (Pal. Soc.), p. 5.

The palæontology of the Red Crag has been carefully studied by Alfred Bell, who, in his paper "On the English Crags" (Proc. Geol. Assoc., vol. ii. p. 185), enumerates 170 species from the Walton Naze deposit, of which 116 are found also in the Coralline Crag. This large proportion of species common to the two deposits is very noteworthy, and when it is also found that there is an absence from the Walton Crag of several forms occurring in the Red Crag of other localities, the evidence is strong for considering the Walton Naze deposit to be older than the Red Crag of Suffolk.

[The next visit of the Association to *Walton-on-the-Naze* took place on June 7th, 1890, W. Whitaker, F.R.S., being Director. Some members, with the Director, stayed at *Clacton-on-Sea* the next day, and noted the interesting cliff section west of the pier, and the remains of the submerged forest west of the town.]

References.

Maps.—Ordnance Survey. Geological. Sheet 48 S.E. 3*s*.
New Ordnance Survey. Sheets 224, 225. 1*s*. each.
Books.—W. Whitaker, Geology of Walton Naze, 8vo, *London* (Geol. Surv.). 1877. 9*d*.
W. Whitaker, Geology of Ipswich, etc., 8vo, *London* (Geol. Surv.). 1885. 2*s*.

EASTERN COUNTIES.

SUFFOLK.

EXCURSION TO THE CRAG DISTRICT OF SUFFOLK.

APRIL 2ND and 3RD, 1877.

Directors—W. WHITAKER, F.R.S; Dr. J. ELLOR TAYLOR, and EDWARD CHARLESWORTH, F.G.S.

(*Report by* Dr. TAYLOR.)

(*Proc. Vol.* v. *p.* 108.)

SOME members came down to Ipswich on the previous Saturday, and were taken by Mr. Whitaker to see the fine sections (from London Clay to Chalk) at Bramford, and those of the Red and Coralline Crag at Bentley and Tattingstone.

The party, arriving at Harwich, proceeded to cross the estuary in small boats to near the new pier at Felixstowe. Thence they went along the railway nearly to the station, after which they walked to the beach. Mr. Whitaker explained the marine denudations which are going on along the Norfolk and Suffolk coasts, and referred especially to the waste of the cliffs at Felixstowe. Afterwards Mr. Henry Miller, jun. (then Hon. Sec. Ipswich Sci. Soc.) produced coloured maps which showed the exact amount both of waste and of addition—the latter, perhaps, being worse than the former, inasmuch as it threatened Harwich harbour.

On reaching that part of the coast where the Felixstowe cliffs begin to appear, just beyond the Bath Hotel, splendidly clean sections were seen which had been cut by the recent storms. Clear-cut vertical slices, measuring forty feet, in many places right down to the London Clay beneath, were visible, exposing the cross-current bedding of the Red Crag in a marvellously distinct manner. Mr. Whitaker drew attention to the lines of cross or

current bedding of the Red Crag, and said that this was a very characteristic feature. He also adverted to the bays or indentations which may be seen here and there, and showed that when these hollows were seen a spring would invariably be found, the fact being that the water which had passed through the Crag beds could not permeate the London Clay, and so formed springs. In doing so, however, it carried away a good deal of carbonate of lime dissolved out of the shells of the Crag, and so caused the Crag section to be hollow where the springs existed. Mr. Charlesworth described the more common species of these beds, and showed how the bivalve shells found with holes drilled through them had been killed by carnivorous Mollusca. He showed that the red whelk (*Fusus antiquus*) and the common dog-whelk (*Purpura lapillus*) lived together in the Crag seas, as they do in existing British seas. But, whereas a child could tell the difference between a *Fusus* and a *Purpura* now, in the ancient days of the Crag these two forms were so nearly alike that, although he had worked as a Crag geologist for nearly half a century, he often found it difficult to discriminate between a Crag *Purpura* and a Crag *Fusus*. The same thing occurred with the genus *Trochus*. It was the easiest thing in the world for a conchologist to tell the difference between living British species ; but it was exceedingly difficult to determine the Crag forms, owing to the extreme variations.

After time for collecting had been allowed, the party proceeded past the Bath Hotel to the clay cliffs beyond Mr. Cobbold's house. These belong to the London Clay. Mr. Whitaker pointed out how all the plants found fossilised in these beds were converted into iron pyrites, and showed the yellow bands of pyrites which ran at even distances along the face of the cliff, at the lines of stratification. The broken and irregular direction of these bands shows that the deposit has been faulted, and he also pointed out how the surface of the London Clay hereabout was hollowed out, and that these hollows must have been eroded before the Pliocene period, for most of them were filled in with Red Crag.

The party then made their way over the cliff, and across the fields beyond, to one of Messrs. Packard's "coprolite" workings. Dr. Taylor showed how these small coprolite nodules were originally deposited in the London Clay, that they could still be found there in the cliffs adjoining, where they were usually met with covered with iron pyrites, and that when the London Clay was worn away, the included phosphatic nodules would be

weathered out and accumulated in seams, the iron pyrites decomposing into oxide of iron, and so furnishing the colouring matter for the Red Crag. The numerous angular and fantastically shaped nodules of flint, usually found at the base of the Red Crag, and often covered on their upper surfaces with barnacles, might have been carried from Norfolk when that county formed the chalky shores of the sea in which the Red Crag was formed, by means of coast or "foot" ice. The "box-stones," he considered, were the broken up and rolled fragments of a geological formation older than even the Coralline Crag, and possibly of Miocene age. About one in twenty of these sandstone nodules—which were so abundant that they were collected, bought, and used for metalling the high roads near Felixstowe—contained casts of shells or, perhaps, fish teeth, or scutes or other remains of crocodiles, whales, and even land animals, such as *Mastodon*. These "box-stones" were always found intermingled with the Chalk flints and phosphatic nodules at the base of the Crag. Sometimes slabs of sandstone were found, very little rounded. Underneath the city of Antwerp, the bed, of which these "box-stones" were here the rolled and broken up part, was to be seen in its natural and undisturbed condition. In reply to Mr. Charlesworth, who thought that the "box-stones" were of concretionary origin, Dr. Taylor said that could not be the case, as a microscopical examination of them showed the angular grains of sand cohering together.

A short stay was made on the way back to the new railway at a pit where Mr. H. Miller showed there were to be found large fragments and whole shells of *Cyprina islandica*. By the kindness of Colonel Tomline and Messrs. Lucas, the party were conveyed to Ipswich along the Felixstowe Railway, not then open. After dining at the Lion Hotel a visit was paid to the Ipswich Museum, where Dr. Taylor delivered a lecture on the new fossils of the "Canham Collection," presented to the Museum by Sir Richard Wallace.

Second Day.—The visitors went by train to Wickham Market. At nine o'clock the party proceeded to Orford, by way of Tunstall Heath, and thence to Chillesford Brick-pit. At the brick-pit Mr. Whitaker explained the nature of the clayey deposit, and described its geographical extent. On leaving this pit and proceeding towards the high road another pit was reached, well known as the Chillesford Stackyard Pit. Here Dr. Taylor described the Crag exposed. One feature, he said, about this

exposure was the larger number and proportion of Arctic shells it contained; *Mya truncata*, *Cardium Greenlandicum*, *Scalaria Greenlandica*, and others, were adduced as evidence that this Chillesford Crag was the latest in deposition, and that its numerous Arctic fossil shells indicated the cold period which was then setting in.

Under Mr. Dalton's direction two pits opened in the Upper Red Crag, near the Butley Oyster Inn, were visited. Many species of shells were obtained, and Dr. Taylor said these pits were well known to conchologists for the number of *fresh-water* shells they yielded—a fact so novel that when fresh-water shells were found in the Norwich Crag it was termed by the late Sir Charles Lyell the "Fluvio-marine Crag." Dr. Taylor thought that the present physical conditions of the Baltic Sea represented the ancient condition of the later period of the Red Crag more accurately than anything else he was acquainted with. In the Baltic, owing to the large amount of melted ice, the conditions were partly brackish; and fresh-water shells might be found living side by side with marine shells.

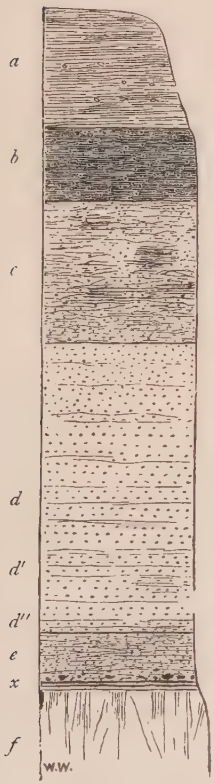
The Coralline Crag,* in its two stages of "Upper Bryozoan Crag" and "Lower Shell Crag," was next to be visited. The party accordingly proceeded three-quarters of a mile beyond Sudbourne Church to a Crag pit, where Mr. Whitaker showed there was an overlap of the Red Crag above the true Coralline Crag, or rather the upper portion of the latter. The Red Crag was bleached by the percolation of water through its loose mass, which had carried down the red oxide to the lower beds, and actually stained the latter a different colour from that in which they are usually found. After leaving the pit three or four hours were passed in examining various other excavations in Coralline Crag near by. The most notable was that to be seen near Sudbourne Park gates. In this pit the geologists found a large number of characteristic fossil Polyzoa, such as *Alveolaria*, *Cellepora*, *Fascicularia*, *Hornera*, &c.

The pits in Sudbourne Park are well-known for the great number of fossil shells they yield, which occur in a lower bed than that of the Coralline Crag proper. Near Sudbourne Hall is a pit showing the outcrop of this bed, and many specimens of such characteristic shells as *Cardita senilis*, *C. scalaris*, *Cyprina rustica*, *Astarte Omaliusi*, *A. bipartita*, &c., were obtained.

* "Coralline" Crag is a misnomer, the remains being those of Polyzoa; Prestwich has adopted Jones and Parker's term "White Crag," which is much to be preferred. (Geology, ii., 1888, p. 418.)

Another outcrop of this Lower Coralline Crag shell-bed was seen at the "Keeper's Pit," after which the entire party made their way to luncheon provided for them by Sir Richard Wallace in the Keep of Orford Castle. The party then returned to Wickham Market, catching the evening train to Ipswich, Colchester, and London.

FIG. 74.—GENERAL SECTION OF THE GREAT PIT, SOUTH OF BALLINGDON, SUDBURY (1873), 8 FEET TO 1 INCH.



a. Brown and grey LONDON CLAY.

READING BEDS.

b. Blackish sandy Clay and clayey Sand, 3 feet.

c. Greenish-grey and mottled sandy Clay, 6 feet.

THANET BEDS.

d. Buff and grey clayey Sand, firm and bedded, about 12 feet.

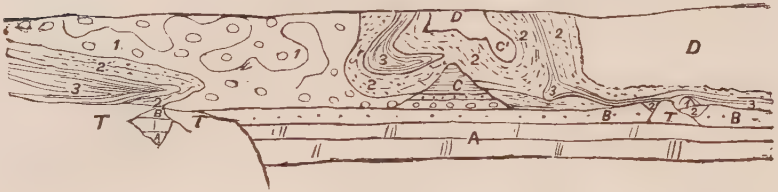
e. Clayey Greensand, with green-coated flints at bottom, and a few higher up, 2 feet.

f. CHALK, with thin layer of tabular flints at *x*.

The beds are even and flat, or with a S.S.W. dip (up to 3°).

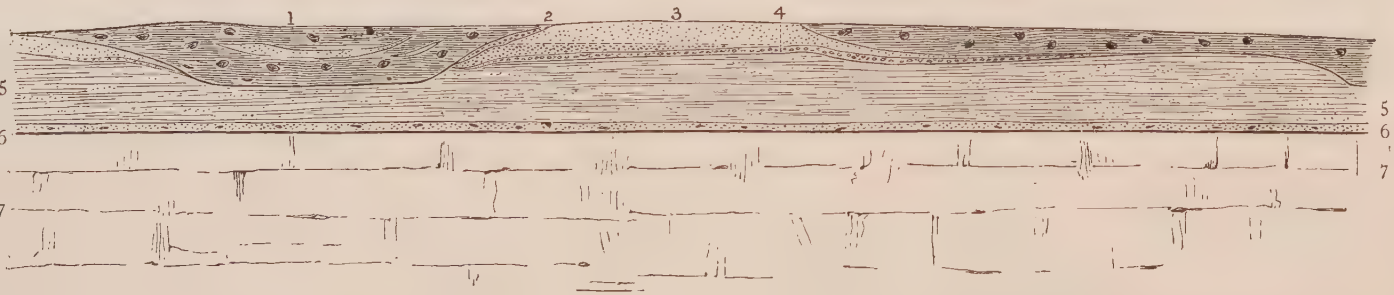
[We learn from the Annual Report for 1863 that *Ipswich* was visited in that year, but no account of the excursion appears to exist. There was an excursion to *Sudbury* (Suffolk) on July 9th, 1887, Dr. J. S. Holden and W. Whitaker, F.R.S., being directors, a report of which appears in Proc. vol. x. p. 187. And *Southwold* and the *Crag District* of *Suffolk* were visited on June 8th-

FIG. 75.—SECTION IN MR. GREEN'S PIT, N.E. OF SUDBURY. (LENGTH 100 FEET.)



A. Chalk. B. Thanet Sand. C. Red Crag. C'. Red Crag caught up in drift. 1. Boulder Clay. 2. Gravel and Sand. 3. Loam. D. Gravel dug over and filled in. T. Talus.

FIG. 76.—SECTION IN A CHALK PIT, EAST OF SUDBURY, 1872.



GLACIAL DRIFT. { 1. Boulder Clay, with patches of Sand. Up to 12 feet.
2. Thin patch of Gravel at one part.

RED CRAG. { 3. Brown ferruginous Sand and yellow Sand. Up to 10 feet.
4. Gravel, chiefly of Flint Pebbles and Ironstone. 0 to 1 foot, with phosphatic nodules.

THANET BEDS. { 5. Grey Sand. Up to 12 feet.
6. Clayey Greensand, with green-coated Flints. 2 feet.

CHALK. { 7. Few Flints. At top alternate thin layers of Chalk and Flint.

11th, 1889, W. Whitaker, F.R.S., and Dr. J. E. Taylor being Directors. Proc. vol. xi. p. 68.]

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NORFOLK.

EXCURSION TO NORWICH AND CROMER.

June 10th (Whit-Monday) and Following Day, 1878.

Directors—F. W. Harmer, F.G.S., Horace B. Woodward, F.G.S., and Clement Reid, F.G.S.

(*Report by* H. B. Woodward and C. Reid.)

(*Proc. Vol.* v. *p.* 513.)

The members took the train to Trowse station, and proceeded through the village of Trowse to the chalk-pit on the Crown Point Estate. Here the Chalk itself, with conspicuous layers of flint, was seen to be tilted up at a considerable angle, and it was overlaid by beds belonging to the Norwich Crag, similarly disturbed. Mr. Woodward pointed out that this was due to glacial agency, for along one face of the pit the entire mass of what appeared to be chalk was re-arranged and mixed up with clay and sand, while it contained not only broken flints, but pebbles

of flint, quartz, and quartzite. This reconstructed chalk had assumed a rude stratification, and partly underlay the solid chalk where it was most highly tilted.

Mr. Woodward briefly called attention to some of the common fossils of the Chalk, exhibiting specimens of the *Terebratula carnea* and *Rhynchonella plicatilis*. The paramoudras formed prominent features in this pit; and it was observed that they were now more abundant here than at the famous pit at Horstead, figured by Lyell.

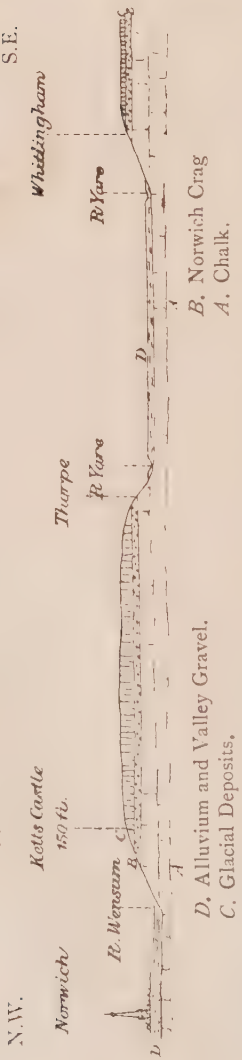


FIG. 77.—SECTION NEAR NORWICH. (DISTANCE ABOUT 3 MILES.)

Concerning their mode of origin, it was stated that they were inorganic, for in shape they passed by gradation into flints of most irregular outline, and often enclosed organisms whose structure was originally calcareous. Possibly the flint collected round some sponge as a nucleus, whose subsequent decay gave rise to the central cavity which characterises the paramoudra.

Referring to the Norwich Crag, Mr. Woodward pointed out that it comprised beds of laminated clay, sand, and shingle, with here and there patches of shells. He had noticed two seams of shells at Trowse. Possibly some of the top beds of sand might belong to the Glacial period, for when the sandy and gravelly beds of this age rested directly upon the Norwich Crag, it was often difficult to draw a line of demarcation.

Mr. Harmer observed that the Chalk exposed on the sides of the valleys of the Yare and Wensum frequently showed signs of glaciation, and, in conjunction with Mr. Searles Wood, jun., he had been led to the conclusion that the valleys had been excavated to a considerable extent subsequently to the deposition of the Contorted Drift, and prior to that of the Middle Glacial Sand and Chalky Boulder Clay.

Leaving Trowse pit the party proceeded through the park (now the property of Mr. J. J. Colman) to the pits near Whitlingham Church. Here the Norwich Crag was again seen overlying the Chalk, and its exceedingly variable nature was pointed out by Mr. Woodward in the larger pit, where shells were visible, and where he had noticed three layers on one face of the pit, while on the opposite side shells were absent. He also drew attention to the occurrence in the Crag series of ironstone nodules, consisting of a hard shell of iron sandstone with a nucleus of clay iron-ore or ochre, and he expressed the opinion that these nodules originated from the segregation of iron oxide around clay pebbles, which are often present in the series, and from which gradations in structure might be traced.

One or two instances of paramoudras occurring in a vertical line were noticed, and Mr. Harmer remarked upon the former presence of a very striking "saddle" or anticlinal disturbance in the Chalk, to which attention was drawn, in 1868, by J. E. Taylor, when the members of the British Association made an excursion to the pit, but which had since been almost entirely worked away.*

With the aid of the map prepared by Searles Wood, jun., and himself, and published in the "Supplement to the Crag Mollusca" (1872), Mr. Harmer pointed out the general relations of the Norwich Crag to the Red and Coralline Crags of Suffolk, and dwelt at some length upon the physical conditions of the area during their deposition.

A halt was made on the river-bank, where flints are dressed for building purposes, and much interest was shown in the mode of flaking, as performed by one of the knappers who practically illustrated the subject.† It was mentioned that gun-flints were still manufactured at Brandon for export to South Africa, and Mr. Woodward exhibited some specimens from that locality.

The members then proceeded to Postwick Grove. Postwick Grove pit was inspected, and the Norwich Crag was seen in places, but, the pit not having been worked for many years, the structure of the beds was not shown. *Tellina obliqua*, *T. prætenuis*, *Mactra ovalis*, *Trophon antiquus*, *Purpura lapillus*, *Litorina litorea*, and other common fossils were obtained.

* See fig. 80, in Woodward's "Geology of England and Wales," ed. 2, p. 468.

† For a full account of the gun-flint industry, see Skertchley, On the Manufacture of Gun-flints, 8vo, *London* (Geol. Surv.). 1879. 16*s*.

Further on, by Thorpe Asylum, a pit in Boulder Clay, which occurred low down on the borders of the Alluvium was pointed out by Mr. Harmer. This he considered to be connected with the excavation of the valley during interglacial times.*

After a short stay at the "Griffin," the party proceeded to the Thorpe Lime-kiln, and the Norwich Crag was found to be very well exposed, and numerous shells were obtained. The stone-bed, which consisted of a bed, one to two feet thick, of flint boulders, was pointed out here, as well as at Whitlingham, and in this bed most of the mammalian remains had been obtained.

Mr. Fitch had in his possession bones and teeth of *Mastodon*, *Elephas meridionalis*, Bear, Horse, Ox, Leopard, Hyæna, and *Trogontherium* from this bed. Mr. Harmer observed, in reference especially to the Mastodon, that it no more belonged to the period of the Norwich Crag than did the flints among which it occurred, and he maintained that it was derived from some earlier deposit in which the remains of the Mastodon had been entombed.† Mr. Woodward drew attention to a hard bed in the Crag Series, which had been cemented by iron-oxide, and exhibited some casts of shells, *Mytilus*, *Tellina*, and *Nucula*, which were to be found at the eastern extremity of the pit.

Proceeding along the lane towards the Plumstead Road, the Lower Glacial beds consisting of brick-earth and sand, which overlay the Norwich Crag, were well seen, and were characterised by the contortions which have led to the application of the term Contorted Drift.

After a walk of about three miles the party proceeded to examine the coarse gravel so well shown in Mr. Moore's pit on Mousehold. This gravel is known as the "cannon-shot" gravel, from the huge rounded boulders of flint of which it is mainly composed. Some igneous rocks and boulders of quartz and quartzite were also observed. In the flints are many casts of echinoderms, and some sponges, which are said not to occur in the highest members of the Chalk exposed at Norwich. Most of the flint-boulders exhibited signs of having been much battered about, and, as was pointed out by Mr. Harmer, they were evidently deposited somewhat rapidly and tumultuously, for the

* See Wood and Harmer, Quart. Journ. Geol. Soc., vol. xxxiii. p. 84. [Many sections in the district are given in this paper.]

† See Quart. Journ. Geol. Soc., vol. xxxiii. p. 138; Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890.

longer axes of the boulders were not unfrequently vertical. It has been suggested that the gravel was formed during seasons of flood, possibly due to the melting of an ice-sheet, an opinion supported by Mr. Skertchly, who, together with Dr. James Geikie, has advocated the land-origin of the Boulder Clay.

Passing to the precincts of Kett's Castle, the party entered the grounds of Mr. J. B. Ladbrooke, who gave the members permission to see the view over the Wensum Valley and across Norwich which is to be gained from the terrace adjoining his house.

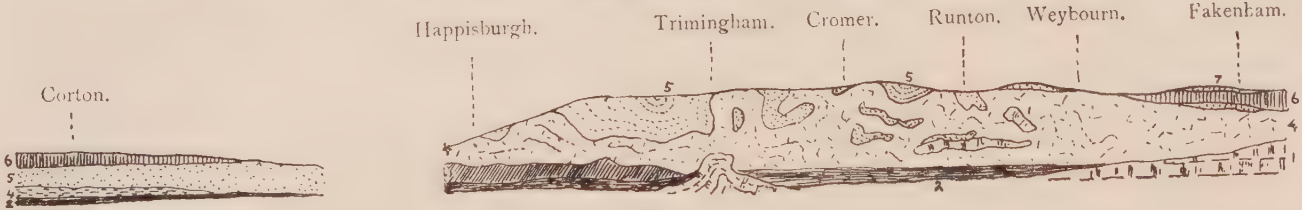
Descending the hill to Bishop's Bridge, the members visited the large chalk-pit near Thorpe Hamlet Church. Here there were seen in one face all the beds in succession from the Chalk upwards to the coarse gravels, which, with the exception of the Boulder Clay, had been previously examined in the course of the day. The Chalk itself had yielded some of the finest remains of the *Mosasaurus* obtained near Norwich. Above it rested beds of sand and gravel with seams of laminated clay classed with the Norwich Crag. Some difference of opinion was expressed by Mr. Harmer and Mr. Woodward, the former regarding certain seams of laminated clay as marking the junction between the Norwich Crag and Lower Glacial series, while the latter included all the beds up to the base of the brick-earth as Norwich Crag. Mr. Harmer pointed out that this brick-earth, which belonged to the Contorted Drift, was extensively worked around Norwich for the manufacture of bricks and tiles.

The party proceeded to the Maid's Head Hotel for the night.

On the following day, the members started by train to Cromer, where conveyances awaited to take them to Sherringham. The route lay across one of the most picturesque parts of Norfolk, and the drive through the grounds of Mr. H. R. Upcher commanded most beautiful views.

After a brief halt at the "Lobster," at Sherringham, the party proceeded along the beach towards Cromer. Attention was at once given to the remarkable contortions exhibited in the brick-earths and sands of the Contorted Drift, while the huge transported masses of Chalk-with-flints excited interest and discussion. One of these masses extended for a length of about 300 yards. Mr. Harmer explained that the contortions were due to the agency which introduced the masses of Chalk, and these masses he considered could only have been borne by icebergs of considerable

FIG. 78.—DIAGRAMMATIC SECTION TO ILLUSTRATE MODE OF OCCURRENCE OF THE GLACIAL DRIFTS IN NORFOLK AND SUFFOLK.



7. Cannon-shot Gravel.
6. Chalky (Upper) Boulder Clay.
5. Middle Glacial Sand and Gravel.
4. Contorted Drift.
3. Cromer Till.
2. Weybourn Crag and Forest-Bed Series.
1. Chalk.

Lower Boulder Clay.

Upper Glacial.

Lower Glacial.

The length of the Cliff Section from Happisburgh to Weybourn is about 20 miles, and the distance inland from Weybourn to Fakenham is about 14 miles. Between Corton and Happisburgh there is a gap of about 20 miles; the portion of the cliff shown at Corton represents about 3 miles. Vertical scale exaggerated, and geological details generalized.

FIG. 79.—DIAGRAM SECTION NEAR CROMER.

6. Gravel, Sand, and Contorted Drift—Loam, Sand, and Marl, with large included Boulders of Chalk.
5. Lower Boulder Clay or Cromer Till.
4. Laminated Clay and Sands, with *Leda myalis*, etc.
3. Fresh-water Loams and Sands. *3a.* Black Fresh-water Bed of Runton.
2. Forest Bed Series—Laminated Clays and Sands, with Roots and *débris* of Wood, Bones of Mammalia, Estuarine Mollusca, etc., in places penetrated by rootlets. *2a.* Weybourn Crag.

} PRE-GLACIAL SERIES.

1. Chalk with Flints.

size. He also pointed out that the sands and gravels, termed Middle Glacial, occupied troughs in the Contorted Drift, and these he regarded as due to interglacial denudation when other valleys in Norfolk were likewise eroded.

Mr. Reid was of opinion that the masses of chalk had been pushed along and not lifted, in many cases having been thrust into the yielding materials after their deposition, and pointed out that they usually appear to have contorted the *overlying* beds, which would not be the case if these beds were of later date. He also observed that the sands and gravels generally identified with the Middle Glacial of Yarmouth are nearly always affected by the contortions in the Contorted Drift.

At West Runton attention was drawn to the succession of the Pre-Glacial Beds.

The Myalis-bed, described by Mr. Reid,* was not well exposed, owing to the talus that obscured the cliffs; but its position was pointed out, and a few decayed specimens of *Mya truncata* were found.

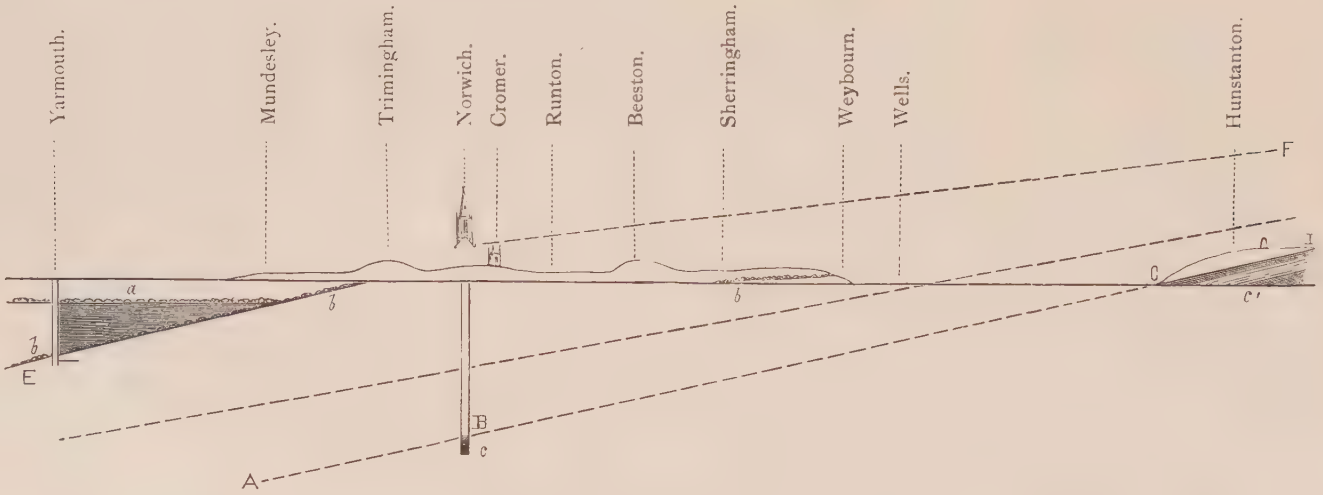
Beneath came the black fresh-water bed, which was so conspicuous a feature near the base of the cliffs. Many fresh-water Mollusca, such as *Unio*, *Paludina*, &c., were obtained; besides these the bed has yielded bones of *Castor*, *Trogontherium*, *Sorex*, *Arvicola (Microtus)*, fishes, insects, and seeds.†

Mr. Reid drew attention to the weathered appearance of the clays immediately underlying the fresh-water bed, and on digging into them several small roots were seen. These roots were not sufficiently well preserved for microscopic examination, but they had the appearance of Yew or Fir. This soil, or Rootlet Bed, he regarded as the weathered upper part of the estuarine Weybourne Beds, which consist of a very variable series of blue clays, sands, and gravel, the last-mentioned occasionally cemented by iron-oxide into a hard conglomerate or "pan." The fossils are equally varied, for at Runton a single bed contained numerous bones of elephant, with cockles, land-snails, and wood; while at other localities these materials are at different horizons. The masses of lignite form the well-known Forest Bed, and often contain the stools of trees, some imbedded in an upright position, others upside down and at various angles. The Forest Bed has

* "Geological Magazine," Dec. II., vol. iv. p. 300. Also Geological Survey Memoir on Cromer (68 E), by Clement Reid.

† C. Reid, The Pliocene Deposits of Britain (Geol. Survey), 1890, price 5*s.* 6*d.*, for full lists and information.

FIG. 80.—SECTION SHOWING THE DIP OF THE CHALK IN NORFOLK, AND THE POSITION OF THE "STONE BED."



a. Bone-bed on surface of London Clay. *b*. Stone-bed on surface of Chalk. A-D. Line of top of Chalk Marl. B. Messrs. Colman's Well. C. High water mark. E F. Top of Upper Chalk.

Yarmouth to Norwich, 18 miles. Norwich to Hunstanton, 40 miles. Dip of Upper Chalk from Norwich to Yarmouth, 29 feet per mile; from Norwich to Hunstanton nearly 29 feet per mile. Dip of Chalk Marl 26 feet per mile and a quarter. [J. Gunn.]

is principal locality visited on the 14th. On the 15th the Trimingham Cliffs were examined. Mr. Reid remarked that speaking generally, the lower part of the Weybourne Beds was marine, and the upper part estuarine, or in places fluviatile. *Tellina balaustina*, a shell as yet unknown in the lowest stages of the Norwich Crag, is abundant in marine beds throughout, and derivative fragments of it are not uncommon in the overlying fresh-water bed of Runton.

Mr. C. A. Sayer has found a Palæolithic implement in the valley-gravel that caps the cliffs at Runton.

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H. B. Woodward, The Glacial Drifts of Norfolk, Proc. Geol. Assoc., vol. ix. pp. 111-129. 1885.

J. Gunn, On the Dip of the Chalk in Norfolk, etc., Proc. Geol. Assoc., vol. iii., 1873, p. 117.

S. V. Wood and F. W. Harmer (quoted above, p. 195).

HUNSTANTON.

[Hunstanton was first visited by the Association in 1867. A second excursion was made there in 1880, both taking place during the session of issue of Proceedings. There is, however, a notice of this second excursion in Geol. Mag., vol. vi. p. 427; Prof. Morris appears to have been director. The report of a third is given below.]

EXCURSION TO HUNSTANTON. MAY 14 AND 15, 1883.

Director—W. WHITAKER, F.R.S.

(*Report by* THE DIRECTOR.)

(*Proc. Vol.* viii., p. 133.)

[This excursion had for its chief object the examination of the neighbourhood of Hunstanton; but it was arranged so as to

allow those members who had time to spare to visit Ely and Lynn.

The Director met the members at Ely on the Saturday, and the party went by boat to Roswell Pit, about a mile below the city, to examine the section laid open there, which was described by the Director and by Mr. M. Fisher, of Ely. This large pit has been made to supply clay for the repair of the walls of the Fen-land dykes, and whilst its northern side is cut in the Kimeridge Clay, the southern gives a fine section of the much newer deposit, the Boulder Clay. The former of these clays is the base on which the eastern part of the great alluvial flat known as Fenland and Marshland is built up, and crops out along the edge of the marshes northward to Lynn, beyond which place it soon sinks below sea-level. It is a dark bluish-grey clay, with layers of septaria or cement-stone, in irregular ovoid masses, formed by the segregation of calcareous matter, and showing the flat, even bedding of the deposit. Many fossils have been found in the Kimeridge Clay here, amongst the Mollusca *Aptychi*, or the opercula of *Ammonites*, being noteworthy. The great interest, however, of the Roswell Pit is in the Boulder Clay, which is a clay more or less full of fragments of various rocks, mostly rounded pieces of hard chalk, but also of older rocks that must have been carried for a long distance from the north, and many of which give clear evidence, by their peculiar scratched surfaces, &c., of the agent which has carried them, namely, ice. In the southern half of this section there occurs an enormous mass of Chalk Marl, Gault, Lower Greensand, and Kimeridge Clay, over 400 yards long, but much narrower, which has given rise to debate amongst geologists, having been at first thought to be a mass of the above-named Cretaceous formations thrown down by a fault against the Kimeridge Clay, but now known to be nothing more than a huge boulder, carried into its present place by ice, and being indeed only a part of the Boulder Clay. That this is so is shown by the facts that the mass in question is surrounded by Boulder Clay, and has also been seen to be underlaid by that clay in places, though unfortunately this cannot now be so well seen as formerly, a great part of the boulder-mass having been quarried away, and the southern side of the pit not being so clear as it was a few years ago.

The ordinary Boulder Clay was well seen at the higher or western end of the pit, where it contained some irregular gravelly masses.

The party then walked to Ely, and, after visiting the cathedral (which is chiefly built of the Jurassic Barnack stone, and contains some very fine, large columns of Purbeck marble and some elaborate work in hard Lower Chalk), spent some time in the museum. The inspection of Mr. M. Fisher's fine local collection gave unqualified satisfaction. Prominent in the collection are the almost unrivalled series of reptilian and fish remains from the Kimeridge Clay of the pit that had just been visited, together with various remains from the peat of the Fenland, and antiquarian specimens from the district, including worked flints, bronze implements, and pottery.

Train was then taken to Lynn.

On Sunday afternoon the party drove to Castle Rising to see the ruins of the castle and church, and afterwards round Sandringham, over the open heathy land of the Lower Greensand, where the scenery is like parts of Surrey, though on a smaller scale.

On Whit Monday a start was made for Hunstanton, and the Director led the party to the southern part of the park, where he showed them a peculiar long narrow winding ridge of gravel and sand, like the similar ridges known as "kames" in Scotland, and as "eskers" in Ireland. This esker-ridge was probably heaped up much in its present shape at the close of what is known as the Glacial Epoch, and it differs from other ridges and hills in the district in that its form results from the heaping up of the materials of which it is composed (as happens in a shingle bank), instead of being due to denudation (or carrying away of materials from the sides), which is the action that has cut out our hills and valleys. The occurrence of eskers in Norfolk had not even been thought of before the Geological Survey of the county was begun. Mr. Holmes, who had worked on that Survey in Cumberland, explained to the party the structure of such ridges in more northern districts, where they are better developed. The return to Hunstanton was made along the pretty, sharp-sided Chalk valley of Ringstead, with its mineral spring, the water of which was tasted by many members, who concluded that it was flavoured with iron to an extent making it just nasty enough to pass muster as a mineral water. In the afternoon a start was made for the pit at the gasworks, where the Director drew attention to the thick mass of sand and shingle there worked, which is in great part crowded with sea-shells of recent species, showing that the deposit is one of late geological age. A northerly course was then taken, and the Boulder Clay at the southern end of the cliff was de

scribed. This thin mass differs from the ordinary Boulder Clay of the district in being of a reddish colour, instead of bluish-grey or whitish, from which it has been thought that it may be allied to the purple Boulder Clay of the Yorkshire coast, or to the Hessle Clay, both generally thought to be of rather later date than our southern deposit; as, however, we have at Hunstanton a fair amount of red beds (of much older date), it is possible that the colour of this patch of Boulder Clay may have been derived from these. [Since this excursion a like reddish or brownish clay has been traced some miles eastward, where no such red rocks occur.]

An advance was then made along the foot of the fine cliff-section for which Hunstanton is noted amongst geologists, but before the members examined the rocks the Director called attention to the principal points of the section, especially with regard to the striking difference of the beds shown as compared with those near London (both to the north and south), with which most of those present were familiar. Thus, in Surrey there is a passage from the clayey Chalk Marl downwards into the Upper Greensand, and from the latter again into the Gault clay, the same succession holding through Kent, except that the Upper Greensand thins out eastward. The same formations also occur on the northern side of the London Basin, in Berkshire, Oxfordshire, and Buckinghamshire, whence a like thinning out of the Upper Greensand occurs north-eastward. At Hunstanton, however, we see nothing of the clayey Chalk Marl, of the Upper Greensand, or of the Gault clay; but, in the place of those deposits, elsewhere from 200 to 400 feet or more thick, we find only four feet of another and wholly different bed, the deeply-coloured earthy limestone known as the Red Chalk, which occurs only in this corner of Norfolk and along the base of the chalk wolds of Lincolnshire and Yorkshire.

Here, too, where from so great an absence of beds we should naturally expect unconformity (or, in other words, that one bed should lie on an irregular or worn surface of that below), we find what, to the eye at least, is conformity; the White Chalk rests evenly, indeed sometimes passes into the Red Chalk, and the latter in its turn has the same relation to the underlying ferruginous grit of the Lower Greensand. This hard grit contains many small pebbles, as well as a few phosphatic nodules and rolled phosphatized Jurassic *Ammonites*, like those which are worked in some districts to the south.

The Red Chalk is lithologically chalk reddened by peroxide of iron, and it ceases to occur a few miles southwards.

There is no doubt about the cause of its colour, but whether the iron formed an original constituent of the rock, or was introduced afterwards from above or below, had not been settled. Many thought the colour to be due to the decomposition of glauconite (green silicate of iron) that originally occurred in the bed; but the Director expressed himself doubtful as to whence the iron had come. Subsequently Professor Hughes remarked on some fissures in the White Chalk that were lined or filled with red iron-stained material; but these he thought furnished no evidence that the iron in the Red Chalk had come from above, as most limestones (of which the Chalk was only one example) yielded on dissolution a red earthy soil. The Cave-earths in Yorkshire and other places proved this. Concerning the geological position or age of the Red Chalk, the Director was disposed to regard it as simply the earliest stage of the White Chalk, or its basement-bed, for although many of its fossils were such as characterise the Gault, and some even belonged to the Upper Greensand, yet many were true Chalk forms. Hence he concluded that the older types of fossils were derived from pre-existing deposits. Had the Red Chalk not been coloured red, he believed no one would ever have thought of grouping it separately from the White Chalk above.*

Attention was drawn to the fossils of the Red Chalk,† which consist mostly of Gault species, but with a large number of Chalk forms; to the hardness of the White Chalk; and to the peculiarity of the lowest two beds of the last. The bed next above the Red Chalk is of a cream colour, and marked by the frequent occurrence of a peculiar branching structure, also found in the top bed of the Red Chalk, which has been doubtfully taken to be a sponge, and known as *Spongia paradoxica* (but which needs further examination), so that the bed, about two feet thick, is known as the sponge-bed; whilst the next above, of about the same thickness, is of a grey colour, and largely made up of fragments of shells of *Inoceramus*, from which it has been called the Inoceramus bed. Professor Hughes gave reasons for regarding the branching structure alluded to as not a sponge, but as being rather of mechanical origin.‡ The rest of the Chalk here consists of the usual hard massive beds.

* See Jukes-Brown and Hill in REFERENCES.

† See Wiltshire in REFERENCES.

‡ See Hughes "On the so-called Spongia Paradoxica." Q. J. G. S., vol. xl. p. 273 (1884).

As the party proceeded, the gentle dip of the beds gradually brought the Red Chalk within reach, and members were able to examine it in the cliff, instead of in the large and mostly overturned fallen masses. Species of *Belemnites* and *Terebratula* were found in the Red Chalk, as well as the coral *Micrabacia*.

From the northern end of the cliff the change in character of the coast was pointed out, there being no cliff for a long distance eastward, but only a tract of marsh, bordered seaward by low ridges of blown sand and of shingle, and landward by a gentle slope. The occurrence of a "submerged forest" on the foreshore nearly at low water-mark was noticed, and the probability of this being merely a seaward extension of an inland peat-bed, which is now laid bare at certain tides, and owes its anomalous position to coast-changes. The other submerged forests of our coasts also occur where alluvial flats come down to the shore.

The walk was then continued to the Waterworks, where the nature of the springs was explained. These are due to the surface of the ground at the inland edge of the marsh being below the saturation level of the water in the Chalk, so that the water flows out. Here, from the absence of any clayey beds between the Chalk and the underlying Carstone, there must be a communication between the waters of these two beds.

The return journey was made along the top of the cliff (after a short detour to Old Hunstanton) whence the remarkable platforms of blocks of hard dark ferruginous grit along the shore could be well seen. These blocks are not boulders, but simply result from the *weathering* of the harder beds of the Lower Greensand along lines of jointing, lines of structure that have been formed after the deposition of the rock, probably by shrinkage accompanying consolidation.

Next morning the party proceeded to Heacham chalk-pit, south-east of the village, which gives a good section of the Lower, or flintless, Chalk. The thickness of the Chalk in Norfolk was alluded to, and the occurrence of flints throughout all but the lowest 150 feet or so; and the prismatic structure often seen along joint-planes or the surfaces of nodular masses was explained as being merely a pseudomorph of arragonite, instead of due to striation or slipping of surfaces.

From the hardness of the Chalk in West Norfolk it has been quarried for building-stone. When there is Gault beneath abundant springs are thrown out, but where that clayey division is absent these are rarer.

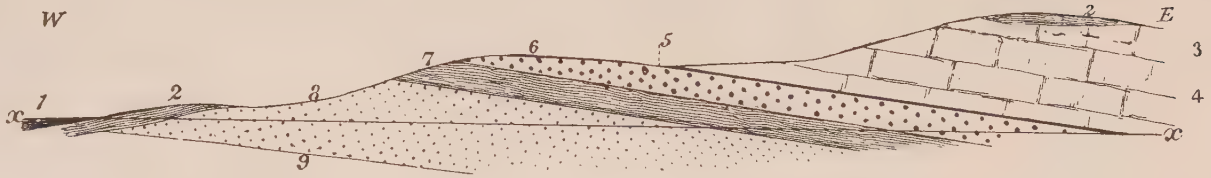
The next section visited was at Heacham Brickyard, where a set of beds below the Carstone (the upper division of the Lower Greensand hereabouts) is worked. This middle division of the Lower Greensand consists of clay, with loamy layers and ferruginous nodules or layers, and reaches a thickness of about 30 feet, thinning southward until it ceases to be traceable. It crops out for the most part on the flank of a hill, and so takes up but small space at the surface; but it is of economic value as being at present the only source for brickmaking in this district. The analogy of these clayey beds to those of a like character and in a like position, known as Sandgate Beds, in Kent and Surrey, was pointed out, and also their still more probable relationship to part of the larger and more fossiliferous Tealby Beds of Lincolnshire. Many fossils, but only in the state of casts and impressions, were got from the nodules of ironstone that occur, the commonest being Neocomian species of *Ammonites* and *Trigonia*.

An advance was made to the gravel-pit on the flank of the hill between Heacham and Snettisham, where the difficulty of assigning a definite geological age or origin to such small isolated patches of gravel was alluded to, it being hard to say whether this one is Glacial or Post-Glacial, though one is led to infer that it is newer than the Boulder Clay (of the higher ground), from the local absence of gravel beneath that clay. The formation of a brown surface-coating, lying very irregularly on the whitish chalky sand and gravel beneath, was pointed out, this being caused, in the same way as pipes in the Chalk, by the action of water, with carbonic acid in solution, sinking irregularly through the gravel and dissolving out the calcareous matter.

One of the Carstone pits, just northward of Snettisham, was visited, and the wonderfully even and regular planes of jointing were noticed, as well as the change in the deposit, from the ferruginous grit of Hunstanton cliff to the bright brown ferruginous sandstone here worked. Some beautifully iridescent surfaces, as richly coloured as a peacock's feather, were noticed on some of the slabs. The Carstone, which forms the uppermost part of the Lower Greensand in the district of Hunstanton and Snettisham, is a sand or grit cemented by iron-peroxide, so as to form a stone that can be quarried for building purposes. At Snettisham only is it worked in dressed blocks for regular ashlar masonry. It hardens somewhat on exposure, lasts well, and has a very pleasing look (albeit irreverently called gingerbread-stone), especially in old buildings, where it is more or less covered by lichen.

FIG. 81.—DIAGRAM-SECTION OF THE COUNTRY SOUTH OF HUNSTANTON (NEAR SNETTISHAM).

(Exaggerated vertically).



x. Sea level.
1. Alluvium.
2. Boulder Clay.
3. Chalk with Flints.
4. Hard Chalk without Flints.
5. Red Chalk (thin).
6. Carstone. } Lower Greensand.
7. Clay and Loam } Lower Greensand.
8. Sand } Lower Greensand.
9. Probable position of Kimeridge Clay.

FIG. 82.—GEOLOGICAL MAP (WITHOUT DRIFT) OF THE NEIGHBOURHOOD OF HUNSTANTON.
[Reproduced from the Map of the Geological Survey, by permission of the Director-General.]

* The Red Chalk has been traced from Hunstanton southwards, to beyond Snettisham.

After an interval for lunch, the other Carstone pit, near the church, was entered, and here the Red Chalk was seen to rest evenly, as at Hunstanton, on the less consolidated upper bed that overlies the massive workable stone. It was noted that the redness was here less than at Hunstanton, and the Red Chalk less massive ; but this latter fact was explained as resulting probably from the Red Chalk in this section being open to surface-actions, the pit not having been carried back to where the White Chalk comes on above. The colour might also be affected from the same cause.

Snettisham Church was then visited, and the last business of the excursion was transacted in the brickyard south of the village, where the clayey beds of the Lower Greensand were again seen. It was noticed how their outcrop could be traced by the growth of oaks, elms, &c., along the flank of the range of hills, as distinguished from the fir-growth on the sandy-beds ; and the outcrop of the sand that occurs beneath this clay at Lodge Hill was pointed out.

During the excursion attention was drawn to the fact that the district bordering the Wash is one on the verge of which the land is increasing at the expense of the sea, the wide alluvial flat of the Fens still continuing to grow seaward, a process that is aided by man, with his reclamation-works. It would seem, however, as if at one time, when the land was a trifle higher than now, the peat, &c., had extended farther north, as shown by the submerged forest of the coasts.

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CAMBRIDGESHIRE.

[On the occasion of the visit to *Hunstanton* at Whitsuntide, 1883, the Director met a number of the members on the previous Saturday at *Ely*, and the party visited Roswell Pit, the cathedral, and Mr. M. Fisher's collection. (See *Hunstanton*, p. 203.) *Cambridge* has been visited by the Association on four occasions. The first was on June 13th, 1862. The party proceeded to *Barnwell*, and examined the extensive excavations in the Chalk-Marl and Gault, and afterwards visited the Woodwardian Museum and some of the colleges, according to a brief report, Proc., vol. i. p. 271. The second excursion, in 1866, took place while no Proceedings were issued. A third visit was made in 1871, and a fourth in 1884, reports of which are given here.]

EXCURSION TO CAMBRIDGE.

APRIL 10TH AND 11TH, 1871.

Directors—Professor J. MORRIS, F.G.S., the Rev. T. G. BONNEY, M.A., and H. G. SEELEY, F.R.S.

(*Proc. Vol.* ii. *p.* 219.)

ON arriving at Cambridge the party proceeded to the Woodwardian Museum, where the collection of Fossil Mollusca was described by Prof. Bonney, who directed the attention of the visitors more especially to the illustrations of the palæontology of the neighbourhood of Cambridge. In this collection are preserved fine examples of the Brachiopoda, found so abundantly in the phosphatic Lower Greensand strata at Upware.

Prof. Seeley then described the Cambridgeshire Reptilian Remains, which form a valuable portion of the Woodwardian Museum.*

Attention was drawn to a skull of *Bos primigenius*, found in the Fens, having an aperture through the bone and a flint implement inside.

Professor Morris then delivered a lecture on the geology of the country around Cambridge.

The geological structure of the country around Cambridge is, he remarked, of considerable interest, both in regard to its influence on the physical features of the district, as well as on account of the economical substances obtained from the strata of the neighbourhood. The geological formations chiefly belong to the Cretaceous system and to the Upper and Middle Oolites, here and there covered by the later Pleistocene deposits. In descending order we find :—

MODERN DEPOSITS...	River Alluvium and Fenland.
PLEISTOCENE.....	Valley Gravels and Clays, with Mammalian Remains.
	Higher Gravels, with Flint and worn fragments of various rocks.
	Brown or Boulder Clay, with Chalk and various other rocks.
CRETACEOUS.....	Lower Chalk and Chalk Marl.
	Base of Chalk Marl. (*Coprolites.*)
	Gault.
	Lower Greensand. (*Coprolites.*)

* "Ornithosauria," 1870; "Index to Aves," etc., 1869; see also Woodward and Sherborn, Brit. Foss. Vert., 1890.

Oolitic	Kimeridge Clay.
	Upware Limestone. (=Coral Rag.)
	Ampthill or Tetworth Clay.
	Elsworth Rock.
	Oxford Clay.

The Fenlands, so well known in the eastern counties, commence near Cambridge, on the Gault, and further eastward are underlaid by the Kimeridge and Oxford Clays. The Valley Gravels bordering the Cam appear to be ancient river-deposits, consisting of the re-arranged materials of the older gravels and of the Boulder Clay, and contain many land and river shells now living in the district, with two species, *Unio littoralis* and *Corbicula* [*Cyrena*] *fluminalis*, extinct in Britain, and associated with remains of *Elephas*, *Rhinoceros*, *Bos*, *Equus*, &c. The higher Gravels and Boulder Clay, containing fragments of rocks brought from various distances, are referred to the Glacial period. Of the two great divisions of the Chalk, the Lower Chalk only, with its characteristic fossils, is seen near Cambridge, the Upper Chalk forming the hills considerably to the east. The base of the Chalk Marl is well exposed at the numerous workings for phosphatic nodules; besides "coprolites" it has yielded the fine series of fossils now exposed in the Woodwardian Museum, including many species of Reptiles (Chelonians, Enaliosaurs, Pterodactyles, Crocodilians, Dinosaurs); Birds; Fish (twenty or thirty species); many species of Brachiopoda, Lamellibranchiata, Gasteropoda, Cephalopoda, and Crustacea, as well as numerous Sponges, Corals, and Foraminifera. The Reptiles, especially the Ornithosauria, have been described by Seeley (see *supra*). The Gault, about 150 feet thick, extends over a wide area, and is well seen at Barnwell. It contains but few fossils, of which perhaps the *Belemnites minimus* is the species least rarely found. The Lower Greensand, exposed at Upware, and reached in deep sinkings below the town (this formation being here source of an Artesian well water supply) is also worked, at Upware, for phosphatic nodules, and contains many fossils, chiefly Brachiopoda, palatal teeth of the fishes, *Sphærodus*, *Gyrodus*, &c., and bones of reptiles (*Iguanodon*), these latter being probably derived from some older deposits. At Potton, Bedfordshire, Iguanodon remains are very abundant in a deposit of similar age. The Kimeridge Clay, well seen at Ely, underlies the Lower Greensand, which latter deposit, however, is also unconformable to other formations in its range southwards and eastwards; this clay contains many fossils, remains of *Plesiosaurus*

and *Pliosaurus*, and the usual characteristic shells, *Ostrea deltoidea*, *Ammonites biplex*, &c. The underlying strata of the Upware Limestone, Ampthill Clay, and Elsworth Rock may possibly represent the Corallian Oolites of other districts, although Prof. Seeley sees good reason, from their fossil contents, for considering the Ampthill Clay only as the true representative of the Coral Rag. The Oxford Clay, forming the great area of the Fenland, is the lowest deposit seen within a limited distance from Cambridge. It is to be found at St. Neots, Huntingdon, &c., and contains many fossils.

Besides the physical features and economical substances to be noted, it is worthy of remark that the geological structure of this district is favourable for a good water-supply, since an abundant supply may be derived from springs above the Chalk Marl, from those rising above the Gault, from superficial gravels, and from artesian wells sunk into the sands between the Gault and the Kimeridge Clay.

The afternoon was devoted to a visit to the Coprolite workings and other excavations at Barnwell. Proceeding along the banks of the Cam a fine section of Pleistocene deposits, yielding mammalian remains and the usual species of mollusca, was examined. This exposure exhibits some beautiful examples of false bedding, and many granite and other boulders from the Drift were seen. Descriptions of this interesting section and its contents are given by the Rev. P. B. Brodie, M.A., "Trans. Phil. Soc. of Cambridge," vol. viii., and by H. G. Seeley, Q.J.G.S., vol. xxii. The last-mentioned paper contains a list of species collected by Mr. Dewick, to which Mr. Alfred Bell has since made additions.*

Mr. Bell writes, "The presence of so many species no longer living in Britain makes this an exceedingly interesting deposit. I refer to *Corbicula fluminalis*, *Unio littoralis*, *Hydrobia marginata*, *Helix fruticum*, *Helix ruderata?* and *Vertigo Moulinsiana*. No other fluviatile deposit that I am aware of contains such an assemblage." A very extensive excavation in the Gault, which is here capped by a thin deposit of Upper Greensand and Chalk, was next visited. The Gault, excavated for brick-making purposes, is exposed to a depth of seventy or eighty feet; and from the evidence of well sinkers it is

* The fullest list is that by Mrs. Hughes, Geol. Mag., 1888. p. 193, who has recently presented a fine series to the Natural History Museum in London.

at this place, probably, from one hundred and fifty to two hundred feet thick. Fossils are rarely met with in the Gault at Barnwell, though in some other localities this formation is very fossiliferous. Lying on the Gault, at its junction with the Upper Greensand beds before mentioned, occurs the stratum containing the phosphatic nodules, incorrectly called *coprolites*, for which this district is famous, and which, though from the Red Crag, were first noticed as being valuable for agricultural purposes by the late Professor Henslow. At a short distance from this excavation the coprolite workings were found on all sides; indeed, the whole of the land was here being systematically explored for these valuable nodules, which lie at an average depth of six or seven feet from the surface. One field after another is taken in hand; the phosphatic bed of about twelve inches in thickness is removed; the soil is carefully replaced on the surface, and the field is then again ready for tillage. Upwards of £100 per acre is paid for the right of working these beds, the contractors being bound to replace the soil, which is generally found to have been improved by the overturning and exposure to which it has been subjected. The so-called coprolites are washed by horse-power, to remove the sand and loam in which they are embedded, and then they are ready for conversion into manure.* A considerable number of fossils, chiefly of Brachiopoda (*Terebratula biplicata* being most abundant), were obtained.

The party returned to Cambridge, and in the evening were entertained at St. John's College, by the Rev. T. G. Bonney.

On the following day, Upware, between Cambridge and Ely, was visited. At this place in the Fens and near to the River Cam very interesting sections have been exposed, in consequence of the search for phosphatic nodules. The Gault, which here becomes very thin, has been cut through, and Lower Greensand strata reached. At the base, as at the top of the Gault, curiously enough, a bed abounding in coprolites is found, and this bed contains characteristic Lower Greensand fossils, together with several new species of Brachiopoda, described by Mr. J. F. Walker. Cropping out within a very short distance from this exposure of Gault and Lower Greensand is a remarkable rock, full of fossil corals, called Coral Rag. This rock, to which Prof. Seeley has given the name of "Upware Limestone," is underlaid by "Ampthill Clay." The Brachiopoda in the infra-Gault coprolitic

* See Proc. Geol. Assoc., vol. i. p. 271.

bed are abundant, especially *Terebratula sella*, *T. prælonga*, and *Waldheima*, or *Terebratella Davidsoni*, many fine specimens of each of which species were obtained, as well as numerous teeth of fishes and reptiles.

In a notice of the strata exposed at this locality, which appeared in the "Geological Magazine," vol. iv. p. 309, Mr. Walker gives full details of the section at Upware, together with a list of the fossils found there.

Mr. Walker remarks that: "This bed and the conglomerate bed near Potton, appear to be of the same age, and probably, also, the Farringdon beds, viz., Lower Greensand, containing large numbers of fossils from other formations."

Mr. H. Keeping has given an interesting section ("Geological Magazine," vol. v. p. 273), showing a "sequence from the Coral Rag to the Gault."

At a little distance from the Coprolite workings and very near to the outcrop of the "Coral Rag" (the "Upware Limestone," of Prof. Seeley), Mr. Keeping had an excavation made of about ten feet, cutting through the Gault, from which he derived the following species :—

Inoceramus concentricus, *Park.*
Nucula ovata, *Mant.*
„ pectinata, *Sow.*
Dentalium ellipticum, *Sow.*
Ammonites interruptus, *Brug.*
„ serratus, *Park.*
Baculites.
Belemnites attenuatus, *Sow.*
„ minimus, *Mill.*

EXCURSION TO CAMBRIDGE.—Whit-Monday and Tuesday, June 2nd and 3rd, 1884.

Director—Professor T. McKenny Hughes, F.R.S.

(*Report by* The Director.)

(*Proc. Vol.* viii. *p.* 399.)

On their arrival, the members met in the Woodwardian Museum.

The collections date from the middle of the 17th century; the oldest being that of Agostino Scilla, described in his work "La Vana Speculazione disingannata dal Senso," which was published in 1670. This collection was acquired by Dr. John Woodward, who continued to accumulate specimens of "native" and "extraneous" fossils in illustration of his views as to their origin until his death, in 1728, when he bequeathed most of them to the

University.* No great addition was made till the time of Sedgwick (1818-1873), who made the museum what it is—one of the richest educational museums in the world.

Mr. Marr explained the arrangement of the Cambrian and Silurian fossils, a collection which had been much enriched by Dr. Hicks. Mr. Harker, assisted by Mr. Small, drew attention to some of the more interesting petrological specimens.

The Association then examined the stones employed in some of the more important buildings. The Mineralogical Museum was next visited, where Mr. Solly pointed out the specimens.

From this the Association crossed to the Museum of Zoology and Comparative Anatomy, where Dr. Gadow explained the arrangement, and gave a sketch of the osteological characters of several of the more uncommon and interesting forms.

The next day the Association examined the geology of the neighbourhood, the general character of which may be seen in the accompanying section (Fig. 83), drawn across the country seen by the members of the Association from the top of the Gogmagogs.

Below them lay the Cam, with its small, sluggish tributaries and broad, alluvial meadows, under which peat was obviously the subsoil along the more northern reaches, as shown by the black colour of the ploughed land beyond Fen Ditton, while gravel filled the valley about Cambridge. Banks and terraces of gravel stood out here and there, some of it re-sorted in recent times, but some of it representing patches of the old Mammoth Gravel which had not been altogether swept away. Remains of Mammoth were not uncommon about Chesterton, for instance, but it was not always possible to determine whether or not they had been washed out of older gravel. These beds were seen on Midsummer Common, and the peat was crossed between Barnwell and Cherry Hinton.

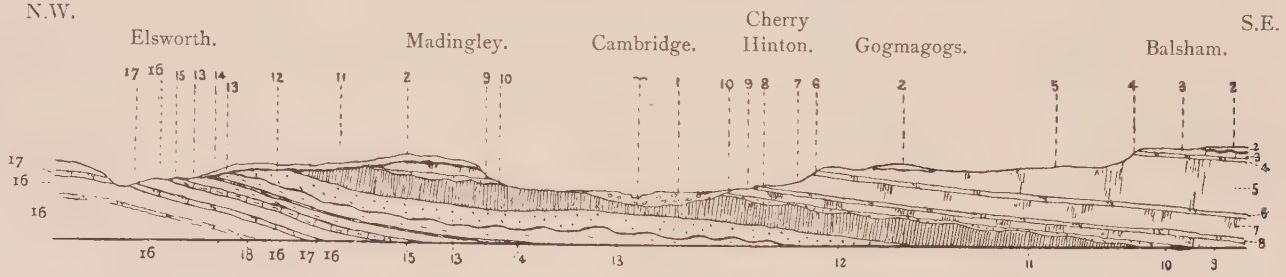
Along the margin of this alluvial plain terraces of an older gravel were observed, which was more closely examined in the Barnwell Gravel-pits.† This same deposit was seen also in the great Gault-pits lapping over the edge of the Chalk Marl, but here it was composed almost entirely of Chalk, so that it was difficult at first to distinguish the chalky deposit which belonged to the gravel

* An Attempt towards a Natural History of the Fossils of England, 8vo, *London*. 1728.

† For a list of the fossils see "Geol. Mag.," 1883, p. 454, and 1888, p. 193.

FIG. 83.—DIAGRAM SECTION FROM ELSWORTH, BY CAMBRIDGE, TO BALSHAM.

(Vertical scale about 800 feet to an inch. Length of Section, 21 miles).



- The Cam and its Alluvium.
1. Gravel.
2. Boulder Clay and Deposits derived directly from its waste.
3. Upper Chalk.
4. Chalk Rock.
5. White Chalk.
6. Melbourn Rock.
7. Cherry Hinton Chalk.
8. Totternhoe Stone.
9. Chalk Marl.
10. Cambridge Greensand.
11. Gault.
12. Lower Greensand.
13. Kimmeridge Clay, with
14. Subordinate Limestones of Knapwell, Littleport, &c.
15. Corallian, with Upware Rock and other Sandy Limestones.
16. Elsworth Rock.
17. Oxford Clay with
18. Subordinate Limestones.

from the underlying Chalk Marl, except where scattered gravel flints were seen in it.

Even in the large Gravel-pits which are further from this small boss of Chalk there is still such a large quantity of Chalk that the surface was seen to be weathered out into pipes and pans by the acidulated water, just as the surface of the Chalk itself is acted upon under similar conditions. In pits on the other side of the hill, nearer Stourbridge Common, this gravel rests on Gault with a very sharp line of demarcation.

Fig. 84.—Section near Stourbridge Common.

Scale 20 feet to 1 inch.

a. Surface soil and residuum of decomposed chalk-gravel.
b. Barnwell gravel, consisting almost entirely of chalk at *b'*.
c. Chalk Marl.
d. Cambridge Greensand.
e. Gault, with lines of phosphate nodules.

A still older gravel was visited on the top of the Gogmagogs, where also the Boulder Clay and a stony superficial deposit, the result of the winnowing of the Boulder Clay, were seen. Around were the Chalk hills, and in the distance, to the north and west, the Lower Cretaceous and Jurassic series rose in gentler elevations. In this walk the outcrop of the Melbourn rock was crossed, but only a few fragments that might belong to that zone were picked up.

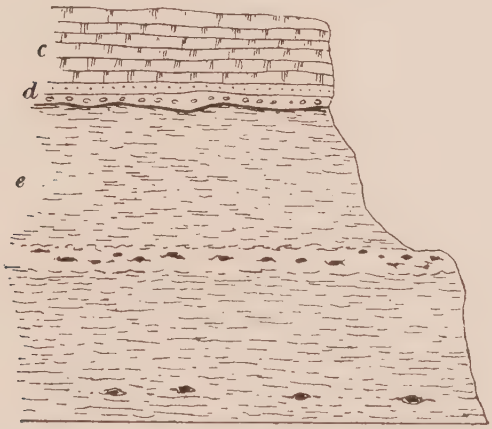
The Chalk between the horizons of the Melbourn Rock and the Totternhoe Stone was well seen in the Great Quarry near Cherry Hinton. Its curious curved joints, often mistaken for bedding, were pointed out, and members obtained a few characteristic fossils.

The Totternhoe Stone was touched in the wooded hollow which marks the site of an ancient chalk-pit nearer the village. It was recognised by the blocky structure and rough texture. Some fossils were obtained here also. A few feet below it water stood in a well in the clayey beds of the Chalk Marl.

The large brick-pit in the Gault at Barnwell (Fig. 85) was visited by the party on their way out in the morning. There the Chalk Marl was seen to pass down into the basement-bed which is called the Cambridge Greensand, from the quantity of glauconitic grains in it, while the very lowest part, full of phosphatised fossils or phosphate nodules, is known as the phosphate-bed or coprolite-bed. Full lists of the fossils will be found in the works referred to below.

FIG. 85.—SECTION IN BARNWELL BRICK PIT.

Scale 20 feet to 1 inch.



c. Chalk Marl—*d*. Cambridge Greensand—*e*. Gault, with lines of phosphate nodules.

This bed was examined more carefully, as well as the method of obtaining and preparing the phosphate nodules, in the pits near Stone Bridge, where many fossils were obtained. Here Mr. Thos. Roberts gave a sketch of the life of the period, illustrating his remarks by the specimens just found.

In the Gault itself fossils are not very common, but along some bands many species may be procured (see Price, *infra*). There are in the Gault also beds of phosphate nodules from which, probably, many of the nodules in the overlying basement-bed of the Chalk were derived.

The Gault was the lowest bed visited. The Lower Greensand and the Jurassic Rocks crop out, as indicated on the section, in the country to the north and west, the features of which were pointed out from the top of the Gogmagogs.

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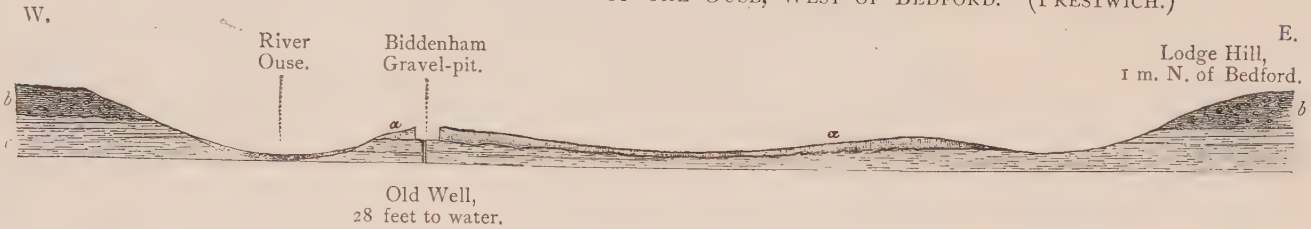
BEDFORDSHIRE.

[On July 25th, 1885, there was an excursion to *Ampthill* and *Bedford*, an account of which may be seen in the Proceedings, vol. ix. p. 222.* Another to *Totternhoe*, *Kensworth* and *Luton*, which was mainly, though not wholly, in Bedfordshire, took place in 1881. For report see p. 225. An excursion to *Bedford* also took place on July 21st, 1888, A. C. G. Cameron being Director. See Proc., vol. x. p. 504. *Totternhoe* and *Ivinghoe* were also visited on June 29th, 1889, John Hopkinson directing: Proc. vol. xi. p. 74.]

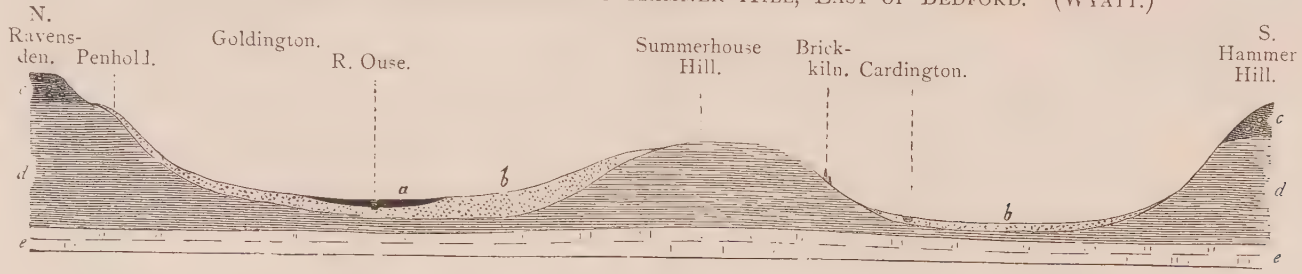
* See figures 86 and 87.

FIG. 86.—SECTION ACROSS THE VALLEY OF THE OUSE, WEST OF BEDFORD. (PRESTWICH.)



a. Subangular Gravel, with Mammalian remains, Fresh-water Shells, and Flint Implements. *b*. Boulder Clays. *c*. Oolitic Strata.

FIG. 87.—SECTION FROM RAVENSDEN TO HAMMER HILL, EAST OF BEDFORD. (WYATT.)



a. Alluvium. *b*. Gravel, with Mammalian remains and implements. *c*. Boulder Clay. *d*. Oxford Clay. *e*. Great Oolite.

(*See p.* 225.)

THIS BREAK IS MADE TO ALLOW OF BINDING IN PARTS CONVENIENT FOR THE POCKET.

BEDFORDSHIRE.

EXCURSION TO TOTTERNHOE, KENSWORTH, AND LUTON.—Saturday, 25th June, 1881.

Directors—Professor J. Morris, F.G.S., James Saunders, and John Hopkinson, F.G.S.

(*Report by* John Hopkinson.)

(*Proc. Vol.* vii. *p.* 191.)

The Dunstable Downs form the most elevated tract of country north of London, within the Chalk area, their highest point, Kensworth Hill, being at least 800 feet above sea-level. The Chalk here forms two escarpments, but the higher beds of the Upper Chalk are not represented, the main escarpment exposing the outcrop of the Lower Chalk and the lower beds of the Upper Chalk, and the secondary escarpment the lower beds of the Lower Chalk and the upper portion of the Chalk Marl with the Totternhoe Stone forming its highest bed.

The party assembled at Stanbridgeford Station at about half-past eleven, and proceeded to the Totternhoe quarries, where a good section of the Totternhoe Stone is exposed.

Mr. Saunders here said that this bed usually occurred in two layers, each about three feet thick, and consisted of a compact gritty limestone, which, in working, separated into massive blocks. Its slightly sandy nature suggested a break in the continuity of the physical conditions which accompanied the depositions of the other beds of the Chalk formation which were almost purely calcareous. The Totternhoe Stone played an important part in modifying the physical features of the district. At its junction with the overlying bed many springs took their rise, the long-continued action of which had been the primary agent in excavating those coombs which were so characteristic of Chalk escarpments. Of these examples might be seen at Ivinghoe, Barton, Ravensbury Castle, and Pegsdon Barns. Of the rarer fossils found in this bed, Mr. Saunders mentioned that he had discovered part of the jaw, with teeth, of *Ichthyosaurus campylodon*, and a crustacean, *Palæga Carteri*, the first of its kind which exhibited the caudal appendages by which Dr. Henry Woodward was enabled to determine the affinities of the species.

FIG. 88. SECTION THROUGH TOTTERNHOE KNOLL AND KENSWORTH HILL, NEAR DUNSTABLE.

Horizontal Scale—1 inch = 1 mile. Vertical Scale—1 inch = 1,320 feet (¼ mile).

U.C. Upper Chalk. *M.C.* Middle Chalk. *L.C.* Lower Chalk. *L.G.* Lower Greensand. *cr.* Chalk Rock. *mr.* Melbourne Rock. *ts.* Totternhoe Stone.

A good many fossils were found, including *Rhynchonella plicatula* and *R. octoplicata*, *Terebratulæ*, *Inoceramí*, &c., teeth of *Ptychodus*, and a fragment of a large dorsal spine of a fish, the only important find. Some nodules of chert were also obtained.

The party then walked across the fields to Totternhoe Knoll, on the summit of which Professor Morris gave an address on the physiography of the district, explaining how some of the Chalk beds were harder than others, and how the varying degree of hardness and softness rendered them more or less liable to the effects of sub-aerial denudation, thus determining the physical features of the country. The Chalk, he said, once extended over a wide area in a north-westerly direction, and had been subsequently removed by erosion. Chalk escarpments, as thus left, which formed such a prominent feature in English scenery, had been inferred to be sea-cliffs, but that could not be the case, for the sea cuts indiscriminately through all classes of rocks, and would have left water-worn flints, pebbles, and sand at the base of the escarpment instead of the unrolled and unbroken flints here seen. After alluding in succession to the most interesting points connected with the physical character and extent of the contiguous underlying strata, the Gault, the Lower Greensand, and the Purbeck beds, Professor Morris referred more particularly to the influence of the range of the Lower Greensand on the physical features

and water-supply of the neighbourhood, illustrating his remarks with a geological map.

Totternhoe was then left for Kensworth Hill. At the foot of the hill a spring was examined, and a discussion ensued as to the stratum which retained and threw out the water on the hill-side, for its position appeared to be above the line of junction of the Chalk Marl (or its highest bed, the Totternhoe Stone), with the more porous Chalk overlying it. The water from the spring had carved out for itself a valley in the Chalk, affording an example of the mode of formation of the coombs.

A steep climb soon brought the party to the summit of Kensworth Hill, where a splendid view of the surrounding country was obtained. On the south the ground was seen to slope gently in the direction of Kensworth, while to the north was the steep escarpment which had just been climbed, with the lesser Lower Chalk escarpment of Totternhoe Knoll and the Maiden's Bower below it, and here and there an outlier of the Chalk might be seen forming a slight elevation on the Gault plain beyond.

The route now lay by Kensworth Green, through Kensworth Churchyard, and across the St. Albans and Dunstable road, to Caddington. Here the carriages were waiting to convey the party to Farley Hill, Luton, where Mr. Henry Brown, President of the Luton Natural History Society, provided tea.

References.

Maps.—Ordnance Survey. Geological. Quarter-sheets 46 S.E., S.W. 3*s.* each.

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BUCKINGHAMSHIRE AND OXFORDSHIRE.

EXCURSION TO TYLER'S HILL, CHESHAM.

SATURDAY, 18TH MAY, 1878.

Directors—Dr. JOHN EVANS, F.R.S., and JOHN HOPKINSON, F.G.S.

(*Report by* JOHN HOPKINSON.)

(*Proc. Vol.* v. *p.* 498.)

AT various places beyond the northern limit of the London Tertiary Basin outliers of the Lower Eocenes occur. One of these, separated from the main mass by a greater distance than is usually the case, is at Tyler's Hill, or Cowcroft, as it is sometimes called, a mile and a-half to the east of Chesham. The nearest railway-station is at Boxmoor, and here a party assembled for the purpose of visiting this outlier.

The distance being five miles each way a waggonette was engaged. An ascent by Box Lane had first to be made, and for about a mile up the hill the Chalk was seen to come to the surface, sections being exposed in several small pits and in the roadside banks, owing to the road being excavated to reduce its steepness.

On the higher ground the Chalk is covered for a considerable distance with brick-earth, and clay with flints. This elevated plateau, some 500 feet above sea level, suddenly ends at Layhill Common, which is approached by a steep descent to the Chalk, here exposed by the erosion of a stream, no longer in existence, which at one time must have joined the Chess near Flaunden. From Layhill Common, where the Chalk is covered by gravel, possibly of Glacial age, there is a gentle rise of the ground towards the outlier, which is conspicuous for some distance through the dense wood which covers it. The presence of this wood seems to be entirely due to the existence of the outlier of which Tyler's Hill is formed. A chalk-pit and brickfields expose a complete section of the hill from the London Clay down to the Chalk.

The following description of this section is given by Prestwich in his paper on "The Woolwich and Reading Series," Quart. Journ. Geol. Soc., vol. x. p. 90.

London Clay.	Gravel, chiefly of flint-pebbles in clay, averages ...	4
	b. Brown clay, with a few nodular septaria	10
	a. Layers of laminated grey and brown clay	3
Basement Bed of the London Clay, 3½ feet.	*c.* Layer of imperfect septaria, full of fossils*	0½
	b. Light brown sandy clay	2
	a. Flint-pebbles in clay	1
Woolwich and Reading Series, 31 feet.	*h.* Umber-coloured clay, in places slightly mottled red and yellow	2
	g. Fine siliceous sand, in places very white	3
	f. Light-coloured soft sandstone, with an occasional pebble—variable	1
	e. Light-coloured siliceous sands, with a few seams of grey clay, the lower part coarser, yellow, and brown	10
	d. Laminated grey and yellow clay and sand, with an under-seam of pebbles	1
	c. Yellow and ash-coloured sand, with seams of grey clay	8
	b. Grey clay laminated with sand	4
	a. Large unrolled flints, apparently white-coated ...	2
		51½
Chalk		25

Several sections exposed in the brickfields at various parts of the hill were examined; and at the Chalk-pit Dr. Evans drew attention to the perfectly level surface of the Chalk, which seemed, he said, to be a surface of marine denudation.

After a distant view of the band of Chalk-rock, which here divides the Upper from the Middle Chalk, the members left Boxmoor Station for Watford and London.

References.

Maps—Ordnance Survey. Geological. Sheet 7. 8*s.* 6*d.*
New Ordnance Survey. Sheets 238, 255. 1*s.* each.
Books.—W. Whitaker, Geology of London Basin, 8vo, London (Geol. Surv.). 1872. 12*s.*

EXCURSIONS TO AYLESBURY.

[The first excursion to *Aylesbury* was made on June 1st, 1870 (Proc. vol. ii. p. 36). A second took place on May 5th, 1873, Prof. Morris being Director, and a brief report may be seen in Proc. vol iii. p. 210. It was again visited on May 29th, 1880, and on June 11th, 1887. The last-mentioned excursion is reported in the Proceedings vol. x. p. 166. An account of that in 1880 is given below.]

* *Ditrupa plana* abounds, together with *Ostrea Bellovicina*, a few *Natica glaucinoides*, a *Fusus*, and teeth of *Lamna*.

EXCURSION TO AYLESBURY.—May 29th, 1880.

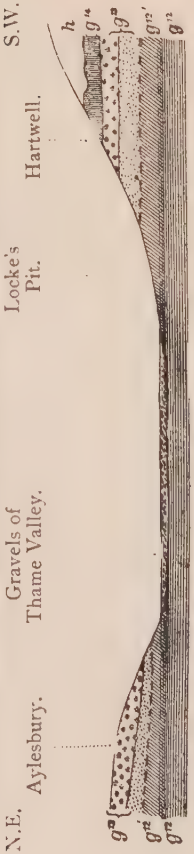
Director—W. H. Hudleston, F.R.S.

(*Report by* The Director.)

(*Proc. Vol.* vi. *p.* 344.)

On arriving at Aylesbury, the first place visited was Mr. Hill's well-known brick-pit on the Bierton Road, where excavations have been going on for nearly a century, and where there is at present a very remarkable and instructive section, which has hardly attracted the notice that it deserves. The appearances in this section are singularly deceptive, and unless they were interpreted by the light of the recent drainage works are calculated to mislead. The clay which is made into bricks is very sandy, and differs considerably from ordinary Kimeridge clay in the nature of its fossils, as does that at Mr. Locke's pit, near Hartwell, which is on the same geological horizon. In Mr. Hill's pit this clay is observed to change colour very much on approaching the surface, and the uppermost four feet are somewhat more sandy, facilitating a change, which is due to atmospheric agencies, and which may be observed in the exposed parts of nearly all clays, though the effects vary according to original composition. Thus a highly fossiliferous clay, such as the top clays at Aylesbury and Hartwell, contains a large quantity of lime salts, which, rapidly yielding to the action of solvents, are often drawn out in the form of an efflorescence, the result being a random aggregation of calcareous matter, and the more or less complete destruction of the shells. That this is a reasonable inter-

Fig. 89.—Diagrammatic Section from Aylesbury to Hartwell.



h. Lower Cretaceous. *g*14. Purbecks. *g*13. Portland Stone and Sand, conglomerate bed at base. *g*12'. Sandy Glauconitic Clay, with *Ostrea expansa*, very fossiliferous (Mid. Portlandian of the French). *g*12. Dark waxy Clay, passing downwards into ordinary Kimeridge Clay.

pretation of the phenomena in Mr. Hill's brickyard is rendered more probable by the fact that the recent drainage excavations have enabled us to observe the perfectly fresh clay, up to its actual junction with the overlying series, in which there is no discoloration, and where the fossils are specifically identical with, and as well preserved as those of the unweathered portions in the brickyards.

The surface of the clay in Mr. Hill's pit is seen to be slightly undulated, a condition which was generally interpreted by the members as due to folding of the strata rather than to the effects of erosion previous to the deposition of the overlying series. Whatever the cause, the result is that towards the south-east part of the pit a slight trough contains a very good development of the basal conglomerate of the Portlands. This also has suffered from atmospheric influences, and few would recognise in its soft and variegated masses the "hard blue" of the drains. Fortunately its lowest bed contains an abundance of small black pebbles, which have withstood the vicissitudes of many a geological revolution, and thus bid defiance to the insinuating action of carbonated water, which has so loosened the matrix containing them. Some quartz is present, but the black pebbles go under the general and convenient term of lydite. These may be derived, some from Palæozoic cherts, others from siliceous beds of mechanical origin, such as are found in the very old rocks. They are extremely hard, but usually contain more alumina than true flint does. Along with these is a very fine series of Portland fossils, here much decayed, but well preserved in the blue bed disclosed by the drains about twelve feet below the surface in the lower part of the Market Place opposite the "Green Man." This fossil bed contains the same sort of ammonites as the underlying clay, but many of the other species are here seen for the first time in England, and continue unchanged to the highest beds of the Portland rocks of this district.

Subjoined is a partial list of the fossils of these basement beds found in the Market Place. The Clavellate *Trigoniæ* were excessively plentiful, and frequently found with both valves. The varieties are so numerous that the identifications are given with some hesitation. The fossils are large and in bad preservation.

Ammonites biplex, *Pleurotomaria ? rugata* (small cast), *Pleuromya tellina*, c., *Pl. Voltzii*, c., *Unicardium circulare*, c., *Cardium Pellati*, r., *C. dissimile*, c., *Trigonia gibbosa*, *Trigonia incurva*, two

varieties c., *T. Pellati*, *T. Carrei*, r., *Mytilus jurensis*, c., *Pecten solidus*, *Lima* sp. r., *Ostrea* distorted forms.

This sudden advent of a partially new fauna was no doubt the result of physical changes in the neighbourhood and the change in the composition of the beds; more especially the presence of pebbles is seen to point in the same direction, and we may suppose that some interval of time elapsed between the deposition of the clay and of the conglomerate.

This conglomerate series is about four or five feet in thickness, and may be observed to have in many places a yellowish-green colour, due to the quantity of green earth or glauconite which it contains; though, like everything else near the surface, it is very much decomposed. But when the soft rock is cut with a knife a green tinge is very manifest. The underlying clay also contains abundance of this green earth, but it requires levigation to separate it, along with the fine quartzose sand, from the clayey particles which invest it.

The formations of the Secondary Period which occupy the Vale of Aylesbury, from the uppermost Kimeridge Clay to the beds which form the base of the Chalk, contain at intervals a large proportion of this green earth. Indeed, the various Greensands have received their name by reason of this peculiarity, though the name in some instances is unfortunate in its application (as are most lithological terms when applied to geological formations) since much of the so-called Greensand is, in its present condition, very destitute of this valuable fertiliser.

The richness of the Vale of Aylesbury has long been proverbial, and really high rents were paid here at a time when a large part of such a county as Norfolk, for instance, was in the condition of uncultivated heath. Many concurrent causes have contributed to this result. Firstly, from one of those accidents which are so difficult of explanation with regard to superficial accumulations, there is hardly any Drift in this region, so that the rich clays and marls of the Secondary formations are not masked by a mass of Glacial rubbish from the north. The two staple formations of the Vale are the Kimeridge Clay and the Gault. These are themselves very rich in phosphatic matter, doubtless arising from the immense quantities of vertebrates entombed therein. But clay alone will not do; we must have lime and sand. These are most happily supplied in the shape of numerous outliers of Portland limestone resting on sands, glauconitic beds, and frequently covered by sands again. The rainwash

of many ages has, from time to time, carried down a portion of these substances and spread them over the clays, so that there has been a happy mixture of the right sort. The Chalk, in the same way, has helped to marl the Gault, though much of that formation is almost a marl itself of prodigious fertility. All that was required in time past has been to remove stagnant water from the land by means of draining, and the best results have been obtained. It can hardly be doubted, however, that dairy farming, and especially the practice of selling the whole milk, so prevalent in this highly favoured district, is very much like spurring a willing horse to the verge of exhaustion. An enormous quantity of phosphate, to say nothing of other substances, is removed in milk. The farmers best know what equivalent they supply. Thus the phosphates at the surface stand a chance of being run out, and although there is probably an inexhaustible store some feet below the surface, it may be questioned how far this is economically available.

The party on leaving Mr. Hill's brickyard passed through the town of Aylesbury. Mr. Robinson, the clerk to the drainage works, was able to point out a section, not yet filled in, on the brow of the hill looking towards Hartwell. The valley of the Thames at Aylesbury is about 250 feet above sea-level, and the summit crowned by the church is, say, 300 feet, making the height of the hill on which Aylesbury stands about fifty feet above the low grounds. More than half of this is occupied by the peculiar type of Kimeridge Clay previously described. Above comes the blue bed with its lydites, &c., also previously described, and above this a few feet of loose yellowish sand. On this sand rest seven or eight feet of white limestone or roach, with thin seams of sand in places. It is not known what occupies the very top of the hill, as the drains were not taken through the summit. About 3 feet of made soil covers all the above beds in succession. The roach represents a certain variety of the Portland limestone, but it would seem as though the very highest beds of that rock were not reached in the drains. The character of the stone and of the fossils would seem to show that part, at least, of the roach at Aylesbury corresponds to the Middle Limestones, which are well developed in neighbouring localities, and which are recognised by a certain assemblage of fossils. Shells, mostly of great size, were thrown out by scores, in various states of preservation, just beneath the George Hotel, when the drain was being carried through the Market Place. Certain beds seemed to be charged

with particular groups of fossils, but as these were for the most part mingled together on the heaps, no very accurate observations could be made. Subjoined is an imperfect list:—

Ammonites biplex, *A. boloniensis*, *Natica elegans*, *Natica?* species, *Pleurotomaria* and *Trochus*, both small; *Pleuromya tellina*, c., *Quenstedtia*, sp., *Cyprina* (two small species), c., *Myoconcha Portlandica*, c., *Lucina Portlandica* or *plebeia*, r., *Caraium Pellati*, r., *Cardium dissimile*, c., *Trigonia gibbosa*, several forms of Clavellate *Trigoniæ* (same with both valves), c., *Arca* cf. *Menandellensis*, c., *Modiola boloniensis*, *Mytilus jurensis*, *Perna Bouchardi*, c., *Pecten lamellosus*, c., *P. solidus*, *Lima rustica*, c., *Lima boloniensis*, r., *Exogyra bruntrutana*.

At the bottom of the hill on the Oxford Road, but rather below its level, there occurs a clay of a very different character from the Hartwell clay of Mr. Hill's pit at Aylesbury and of Mr. Locke's pit at Hartwell. This also was exposed in the drains. A short search for fossils in this clay did not disclose anything very remarkable, though an ammonite different to the form so characteristic of the uppermost clay was noted. Still the usual fossils of the Kimeridge Clay were not found. A very sandy stratum is said to occur below this again, but the authority for the statement may be doubtful.

The party reassembled in Mr. Locke's brickyard, which, in its its geological position, is analogous to the one described at Aylesbury. The Hartwell clay is here seen at the south-western end to be overlain by a somewhat altered representative of the glauconitic or lydite series, which forms the base of the Portland rocks in this part of the country. It is fully five feet thick, and the bottom bed, which contains the bulk of the lydite, is not easily uncovered. The beds are also much more calcareous than the equivalent series at Aylesbury, and less decomposed. On the whole, too, they are more varied, and the glauconitic character is much less marked. Very few fossils were obtained from the Hartwell clay on this occasion, the time of the year not being favourable. The Director, however, briefly commented on the nature of the fauna, as shown in the collections which have been made from here, pointing out that three most characteristic fossils of the Kimeridge Clay, viz., *Rhynchonella inconstans*, *Ostrea deltoidea*,* and *Exogyra virgula*, have never yet been found. The fossils

* The particular form found at Hartwell is now called *Ostrea expansa*.—H. B. W.

prove it to occupy a higher horizon than the Kimeridge Clay at Oxford for instance. It is, in fact, on the horizon of the Middle Portlandian of Boulogne, as was maintained by M. Edmund Pellat, when the Geologists' Association visited the Boulonnais two years ago, under the direction of that distinguished Jurassic geologist.

The following partial list may serve to show the character of the fauna :—*Belemnites Souichii*, *Ammonites biplex* two forms. Gasteropoda are rare in the upper clays ; a *Cerithium* near to *septemplicatum* is the most common, and a *Pleurotomaria* very like *rugata* occurs. *Pleuromya tellina*, c., *Pholadomya* cf. *tumida*, r., *Thracia tenera*, c., *Corbula* cf. *Bayani*, c., *Cyprina implicata*, c., *Astarte Hartwellensis*, c., *Astarte Sæmanni*, *Ast. scalaria*, c., *Lucina lineata*, r., *Cardium morinicum*, c., *Trigonia Pellati*, *Trigonia* near to *incurva*, *Arca texta*, c., *Mytilus autissiodorensis*, c., *M. Boloniensis*, c., *Pinna suprajurensis (Constantini)*, *Perna Bouchardi*, c., *Avicula octavia*, *Pecten Morini*, c , *Ostrea* near to *expansa*, c., *Ostrea bononiæ*, c., *Exogyra bruntrutana*, *Exogyra carinata*, *Waldheimia boloniensis*, r., *Rhynchonella subvariabilis*, r. The variety of Oysters is very remarkable, and some forms of this genus are, perhaps, almost unknown elsewhere.

Thence the party proceeded to the "Bugle" pit, where the junction of the Portland limestone with the Purbecks may be seen. Following the sequence from Locke's clay-pit it is possible to calculate with tolerable accuracy the thickness of the Portland rocks at Hartwell. We calculate from below upwards. Above the Hartwell clay the impure limestones and glauconitic sand associated with the lydite bed have a thickness of five feet. In the "Bugle" pit, what seems to be the top of this series is known as the blue bed, and above it lie four and a-half feet of loose yellowish sand. Next above the loose sand come two feet of hard building stone, with few or no fossils, and above this again comes the main body of the Portland limestone. This, including partings of a variable nature, measures nine feet, so that the entire Portland series to the base of the Pendle of the Purbecks is probably under twenty feet. The fossils which come from these upper Portland limestones are well known, and many specimens of *Ammonites boloniensis* have been built into the wall of Mr. Lee's park. The most curious thing is, that with the exception of certain species common to all the Portland Beds, the fossils here are very different to those in the stone found in the Aylesbury drains. These limestones, in fact, belong to the Upper

series, whilst those at Aylesbury belong to the Middle series. This is intelligible enough, but where is the Middle series at Hartwell?* We have the bottom series (basement or blue beds) and the top series, but the middle series is wanting, or has assumed another form. Such a fact serves to show how variable in their development these Portland rocks must be. The Purbeck beds of this quarry have not yielded many fossils, but some others in the neighbourhood have furnished insect remains and certain varieties of fishes. The beds are estuarine in character.

The remainder of the formations occupying the surface on the high grounds towards Stone are of a very sandy nature. It will be observed that there is a considerable degree of inclination in the pits and quarries hereabouts, whereby a certain degree of irregularity is imparted to the relative position of the beds, so that without the aid of fossils their precise geological position is uncertain, beyond the general fact that they are of Neocomian age. The white sand-pits show many feet of nearly pure white sand with here and there layers of carbonaceous particles. The probability is that these sands have been bleached by the action of organic acids, arising from the decomposition of woody or at least vegetable matter which has run out the iron and other soluble substances, leaving a nearly pure silica. The very best quality has been much used for glass-making, but is at present undersold by sands enjoying superior facilities of carriage. In the principal sand-pit on the northern side of the main road there are a number of siliceous concretions of a peculiar strangulated appearance, long known to the country people as "the Doctor's bowels:" some of these are built into the park wall along with the ammonites. It was observed that the texture of this stone is different from that usually known as Sarsen-stone, being much coarser.

The Director led the way to the summit of the Round Hill, whence there is a magnificent prospect of the Vale of Aylesbury looking south in the direction of the Chilterns, and also looking north over the valley of the Thame. The topography of the region as subordinate to its geological structure was indicated. The innermost line of Portland rocks (sometimes covered by

* Until the rock has been pierced right down to the Hartwell clay there is really no satisfactory evidence as to the thickness of the Portland Rocks —W. H. H.

Purbecks and Neocomians) parallel with the Chilterns, has a length of ten miles from Thame to a little beyond Aylesbury. Upon a portion of this continuous mass the party were now standing. It has the River Thame as a sort of wet ditch on its northern flanks. This flows over Kimeridge Clay. The first system of outworks beyond the line of the Thame is to be seen in the ridges of the Winchendons, of which Colney Hill is the eastern extremity, though the little outlier of Weedon belongs to the group. The second and still more isolated system of outworks is to be sought in Ashenden, Lodge Hill, and the very large outlier which supports the villages of Pitchcote, Oving, and Whitchurch. The most detached summit of all is Quainton Hill, forming part of a third series of outworks. The Portland rocks are probably thicker at Quainton (they certainly are at Lodge Hill) than at Hartwell, indicating a tendency to thin out to a feather edge on the south. They also show a mean fall of between 300 and 400 feet in the seven miles, giving a dip of about half a degree to the S.S.E. All this cutting away of the intermediate rock is the result of aqueous agencies, determined most probably in the first instance by folds in the beds. Reverting now to that far more distant period when the Portland rocks, instead of being carved out into separate hills, were being laid down as sediment not yet consolidated in the waters of a shallowing sea, the Director speculated on the possible shore-lines of such a period in this area. The remarkable analogy which in some respects the Portland beds of Bucks present to those of the Boulonnais, which all geologists agree were deposited not far from a promontory of the old Ardennes ridge, might lead to the supposition that the influences of such a ridge, even if not actually above water, have made themselves felt in the migrations of mollusca, and also in the nature of the deposits, though those of the Boulonnais are even more sandy than in Bucks, where there is at least one tolerably pure limestone. From recent borings the undulating character of the old Palæozoic floor, upon which the Secondary beds must rest, may be inferred, but it is equally clear that the Mesozoic column becomes thinner as we advance northwards from London, as shown by the boring at Ware which reached Silurian rocks at a depth of about 800 feet. It is also equally certain that the Jurassic rocks are absent altogether beneath Ware. We cannot therefore expect that these various beds seen to-day, including the clays on which they rest, have any great extension within the Chalk area, beneath which we see

them dipping. Somewhere between here and London they are sure to knock up against the old rocks, and when we remember the oscillations that have taken place at various epochs, it is not difficult to believe that, during the Portland period, either a shore line or a line of rocky shallows was not far off in a south-easterly direction. At present the thickness of the Secondary rocks here may be about 1,000 feet; they are 800 feet thick at Ware, 30 miles to the east, and 1,200 feet thick at Burford, 36 miles to the west. The boring at the Asylum, near Stone, close by, went through 570 feet of beds, and terminated somewhere in the Oolitic formation.

For a long period, in the interval which preceded the deposition of the Chalk, this region underwent considerable vicissitudes, accompanied by much denudation. Then came a time when the whole region, far and wide, sank, and the Cretaceous sea flowed over everything for ages. The story of the uprise of its deposits and of their sculpture, whereby the great escarpment of the Chilterns was produced, belonged to another chapter in the chequered history of the earth.

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[*Oxford* was first visited by the Association on May 20th, 1861 (Proc. vol. i. p. 155). A second excursion took place in 1864, and a third in 1869, during the period when Proceedings were not issued. A report of the next is given below.]

EXCURSION TO OXFORD.—May 12th and 13th, 1871.

Directors—Professor John Phillips, F.R.S., and J. P. Earwaker.

(*Proc. Vol.* ii. *p.* 243.)

The members were received by Professor Phillips, who described the Museum, its arrangement and contents, especially referring to the unique collection of the remains of *Cetiosaurus*.

The party proceeded to Shotover Hill, examining by the way the excavations in the Oxford Clay near the city, and the exposures of the Coral Rag and of the Kimeridge Clay on the side of the hill, and on returning were entertained at dinner by Mr. James Parker, who afterwards gave a *soirée*, and exhibited his valuable collection of reptilian remains and other fossils from the neighbourhood of Oxford.

On the second day an early visit was paid to Merton College for the purpose of enabling the members to inspect the large collection of fossils which Mr. Earwaker, of that College, had brought together.

Subsequently the party started by carriage for Islip, Enslow Bridge, and Kidlington. At Islip a fine section of the Forest Marble and Cornbrash, with the usual fossils of these formations, is exposed; and an Ammonite, probably the first from the Cornbrash of this district was found [Phillips records *Ammonites discus* from the Cornbrash of Kirtlingtow. Geol. Oxford, &c. p. 243 (1871)]. The village of Islip is, however, interesting to geologists on other grounds, for here lies Buckland. Around the tomb of the great geologist, with his distinguished successor at their head, the party assembled. The memorial is of polished Aberdeen granite, and the inscription briefly records the fact that there lie the remains of Dr. Buckland, Rector of Islip, Dean of Westminster, and First Reader in Geology in the University of Oxford.

The quarries at Enslow Bridge, which have yielded a large number of the Saurian bones now in the University Museum, were then visited, and here the members were highly gratified to learn that during the morning a very fine skeleton of *Teleosaurus* had been found, and the head was exposed to view. This quarry is in the Great Oolite (see Prestwich, Geology, ii. 1888, p. 208), the lower and uppermost strata of which in Oxfordshire yield remains of *Megalosaurus*, while in the middle beds we find *Teleosaurus*. A very remarkable bed, about twelve inches thick, occurs a little above the *Teleosaurian* zone, crowded with *Terebratula maxillata* to the exclusion of every other species.

Several other sections of the great Oolite, Forest Marble, and Cornbrash were examined.

[An extended report of an excursion to Oxford in 1869, by James Thorne, was published by the Association as a separate pamphlet in that year.]

EXCURSION TO OXFORD.—April 6th and 7th, 1874.

Directors—Prof. Phillips, F.R.S., and James Parker, F.G.S.

(*Report by* W. H. Hudleston and James Parker.)

(*Proc. Vol.* iv. *p.* 91.)

The party met in the New University Museum at noon, and were received by Professor Phillips.

The following is a brief abstract of Professor Phillips' remarks: "The valley, in which Oxford is situated, is cut down to the Oxford Clay but there is a quantity of low level gravel, which, in the promontory between Thames and Cherwell, on which the city stands, usually attains a depth of from 8 to 20 feet. In composition it is mostly oolitic, but with some admixture of materials from the high level gravel, which is often found capping the plateaux of the district. These materials are chiefly quartzites, felstones, and grits, but flints are also found. Elephants' teeth are abundant. Therefore, at a time when these gravels, which are of fluviatile or lacustrine character, were deposited, great herds of elephants must have roamed over the slopes bordering on the valleys of that district. There is no action of the present Thames now in force which would produce such a deposit. The Oxford Clay hereabouts is of great depth, but appears to contain little or no trace of the Kellaways Rock, which, in Wiltshire, on the one side, and in Yorkshire on another, forms such a rich and characteristic fossiliferous zone towards the base of this series. Fossils are not particularly plentiful about Oxford: there are, however, several species of *Ammonites*. At a brickyard in St. Clement's, a suburb of the city, many specimens of *Ammonites vertebralis* may be obtained. This is towards the top of the formation. It is succeeded by the Calcareous Grit, about 70 feet thick, a loose sandy rock, in parts cemented by carbonate of lime. The Coralline Oolite, or Coral Rag, which succeeds, is about 50 feet thick, and extremely full of fossils, especially of corals. Amongst these *Thecosmilia annularis* and *Isastræa explanata* are very numerous. From the position in which these masses are now found it is not probable that they represent actual coral reefs, such as are at present growing in enormous vertical proportions in the Indian and Pacific Oceans; but rather that they are the result of drifted masses, like the Bermuda Reefs, partially grown over by other

corals and much frequented by Gasteropoda. The Echinodermata of this formation are well known for their beauty, but specimens are not so plentiful as in Wiltshire and Yorkshire. The spines of *Cidaris florigemma* are plentifully scattered about at Bullingdon, &c., and some fine specimens of *Cidaris Smithii* are occasionally obtained. Brachiopoda are remarkably rare; but there is a goodly list of ordinary bivalves and univalves. *Lima* and *Pecten* are well represented, *Lima leviuscula* being remarkably fine and characteristic. *Chemnitzia Heddingtonensis* is most conspicuous amongst the univalves. Kimeridge Clay, about 100 feet in thickness, rests immediately upon the hard Coralline Oolite, the surface of which appears to be water-worn; a few feet above the junction there is a thin calcareous band. In the lower part occur selenite crystals of good size, clear and well formed; the upper parts are the most fossiliferous, and abound with the remains of saurians. *Ostrea deltoidea* is throughout the most characteristic fossil. The Portlandian beds, which succeed, consist mainly of sands, occasionally glauconitic, in which occur huge lumps of stone, seeming to be for the most part concretions round organic objects. Numerous Portlandian fossils occur in these. It is a remarkable circumstance, as indicating the recurrence of a species apparently extinct, that the beautiful little *Littorina muricata*, so characteristic of the Coralline Oolite, should, after the lapse of the entire Kimeridgian period in this region, reappear as a Portlandian fossil. There seems, however, to be more than one instance on record of its occurrence in the Kimeridge Clay itself. The Portland Sands are the last marine beds of the Oolitic system on Shotover Hill. They are covered, without any apparent disturbance of the sea-bed, by about 10 feet of the 'Ironsand series,' the Oxfordshire equivalent of the Wealden, deposited probably near the rim of the basin. *Unio* and *Paludina* are of not unfrequent occurrence, though not likely to be found when no especial excavations are going on. A fern leaf was accidentally picked up by Mr. Brodie, and handed over before the value of the prize had been noticed. On another occasion Mr. Parker had caused some excavations to be made in a field at the top of the hill, when he found some very fine *Unios*. These beds contain a considerable quantity of ochre, but in the ochre-pits little of importance seems to have been found. The iron ores are probably too siliceous to be of much economic value." Professor Phillips concluded his remarks by showing the great amount of denudation which the Oolitic and Wealden beds had probably undergone in some places

before the deposition of the marine beds of Lower Greensand age, and instanced as a proof of this the accumulations at Potton.

The Professor then proceeded to point out in the Museum those portions of the collection illustrative of his lecture. Amongst many interesting fossils are some beautiful examples of *Ammonites catena*, a large ammonite (most probably *A. perarmatus*) out of which the shelly matter having been dissolved, the casts of the chambers hang loosely together like the links of a chain. These specimens are from the Calcareous Grit of Marcham.

The party, under the direction of Mr. Parker, then proceeded in the direction of Shotover to verify the sections just described.

On the following day Professor Phillips personally conducted the party to Charlbury and was assisted by Mr. Parker.

The plan of the excursion was to walk from Charlbury to Handborough, a distance of seven miles from W. to E. In the course of this excursion the following formations might be observed, *viz.* :—

		Ft.
Marlstone		16
Upper Lias		10
Inferior Oolite		12
Great Oolite	Stonesfield Slate	
	Great Oolite	
	Forest Marble	
Cornbrash		6

On commencing to walk back from the Charlbury station along the line the party passed through a cutting of Inferior Oolite. The Oolite here is a pale yellow ragstone containing a fair number of shells, belonging to the *Clypeus*-grit, which is probably the topmost member of the *A. Parkinsoni*-zone. *Terebratula globata* (*subglobosa ?*), *Rhynchonella concinna*, *Myacites Jurassi*, *Pholadomya media* (*Ag.*), *Homomya gibbosa*, and *Clypeus Ploti* frequently occur in these beds. Besides these several others were found, as *Gresslya*, *Ostrea crassa*, *Ammonites Parkinsoni*, &c. Some paler coloured and more fissile limestones, which in some parts of the cutting are observed to set in just above the ragstones, Professor Phillips was disposed to refer to the base of the Great Oolite. These yielded teeth of *Acrodus* (*?*). A slight fall in the line on leaving the cutting leads to lower beds opposite Fawler, where the Marlstone has been excavated for ironstone. Here there is a fine section, exhibiting the Marlstone,

Upper Lias, and Inferior Oolite, one above the other, in most striking contrast.

The whole section cannot exceed forty feet; this is all that represents beds, attaining at Cheltenham (thirty miles to the west), a thickness of 600 feet. The Upper Lias consists of blue sandy clays, not known to contain fossils, and on this rests the yellow, rubbly Inferior Oolite. A most remarkable feature here is a thin bed of rolled shells and pseudo-pebbles, like the Dogger of the Yorkshire coast, and occupying an analogous position. Instead, however, of *Terebratula trilineata*, the chief shell here is *Rhynchonella tetrahedra*, of large size. This bed occurs between the Upper Lias and the Inferior Oolite. It seems to partake of the colour and nature of the latter.

The party then proceeded in the direction of Stonesfield, under the guidance of Mr. Parker. The slaty beds of this portion of the Great Oolite occupy some highish ground between Fawler and Stonesfield. Mr. Parker pointed out the method of winning the slate. This is done by means of pits, into which the workmen descend to the bed whence the slate is extracted. Piles of *débris*, the results of ages of work, encumber the hill-side. By far the most characteristic fossil is *Trigonia impressa; Gervillia acuta* is also far from scarce. A portion of a bone of a pterodactyl, *Rhamphorhynchus Bucklandi*, was found.

Some members descended by means of a rope and loose ladder to the bottom of one of the "wells," to see the nature of the workings. The scene from any of the numerous eminences is a very striking one. The enormous heaps of broken slates over which the grass does not grow meet the eye in every direction. From the time of the Romans, throughout the Middle Ages, the stone has been the chief roofing material throughout the district; but, in consequence of the railway communication, it has found a serious rival in the Welsh slates, the extensive use of which threatens to put an end to the working of the pits here.

The party then descended by the eastern valley, close to the line of the old Akeman Street, and regained the railway. Here some fine sections of Great Oolite, representing beds in the aggregate from thirty to forty feet in thickness, were visible. The characteristic Great Oolite fossils were not abundant, but a bed of marl at one spot produced large quantities of *Nerinæa* (*N. Eudesi* and *N. Voltzi*) and a small *Astarte*. A few specimens of *Terebratula maxillata* were found, but the remarkable bed of this brachiopod which occurs at Kirtlington is wanting, or at

least is not exposed. The section along the railway is interesting, but difficult of interpretation. Going along the line one meets with what appear, at first sight, to be vast curved escarpments, with the Evenlode winding along the base, and so passing and repassing the railway. The strata, however, so far as they can be observed, are almost horizontal, and the series of cliffs (which have a general direction of north to south, while the main line of the Evenlode is west to east) must be accounted for in some other manner.

The remains of a Roman villa near here were also visited.

Within half-a-mile of Handborough Station the Great Oolite was lost, and was succeeded by the clays and shelly limestones of the Forest Marble. These were admirably exposed. The surfaces of the beds exhibited traces of fish, *e.g.*, palates, teeth, and scales. A few shells, mostly imperfect, were seen. A bed of grey argillaceous shales, about ten feet thick (not fossiliferous), separated these beds from the yellow rubble, above which is the Cornbrash, which nowhere exceeds six feet in thickness. It did not in this place yield many fossils, but several specimens of the characteristic *Terebratula intermedia* were found scattered about.

The party then proceeded to Oxford.

[This excursion of the Association to Oxford will always have a melancholy significance for those who took part in it. None who heard the words and witnessed the vigorous actions of the veteran geologist who led the party through the Charlbury Cutting could have anticipated that fatal stumble, which, not quite three weeks afterwards, deprived the Geologists' Association of a kind friend, and the world at large of an earnest and philosophic inquirer after truth.]

EXCURSION TO OXFORD.—Whit-Monday, May 17th, and following day, 1880.

Directors—Prof. Prestwich, F.R.S., and James Parker, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* vi. *p.* 338.)

The party was received by the Directors, when Prof. Prestwich commenced a demonstration of the palæontological collection in the University Museum, directing attention more especially to the fossils from the neighbourhood

Amongst the Portland fossils are some very fine specimens of *Ammonites pectinatus*, a new species figured but not described by Phillips in the Geology of Oxford. In the Kimeridge Clay of the neighbourhood *Rhynchonella inconstans* occurs sparingly towards the base, and *Exogyra virgula* is tolerably common, but *Ostrea deltoidea* is reported to be scarce. A somewhat unexpected circumstance is the occurrence of *Rhynchonella inconstans*, in what appears to be a Corallian matrix, from the neighbourhood of Marcham.

The Oxford Museum is especially rich in the remains of the vertebrates from the various Oolitic beds of the neighbourhood, ranging from the small mammals of the Stonesfield Slate to the huge *femur* of the *Cetiosaurus* from Kirklington (the *magnum bonum* of Prof. Phillips). The Professor alluded also to the recent discovery in the Kimeridge Clay of *Iguanodon Prestwichi*, a new species of that peculiar genus of Dinosaurs, which had not previously been discovered in strata older than the Wealden.

After enjoying the hospitality of the Directors the party proceeded eastward in the direction of Shotover, under their guidance. Mr. Parker had provided for the use of the members a detailed octavo tract, containing a map and sections of the strata south of Oxford, with explanatory text. The strata represented on the map in ascending order are—

"1. *Oxford Clay*, on which Oxford itself is situated.

"2. *Lower Calcareous Grit*, resting on the Oxford Clay, and followed by

"3. *Coral Rag Series*. This is in part covered by

"4. *Kimeridge Clay*.

"5. The *Portland Sands* (including Portland Rock) follow on the Kimeridge Clay, on ascending Shotover Hill, and appear to some extent further eastward.

"6. The *Iron Sands*, capping Shotover Hill (east of Oxford) and Cumnor Hill (west of Oxford); attributed by some to Wealden, by others to Lower Greensand.

"To the south-east the Kimeridge Clay is covered by the ordinary Cretaceous Beds. The sands here are referable to ordinary *Lower Greensand*, and these are further on covered by

"7. The *Gault* in which a few fossils are found, but only in one or two places. The *Upper Greensand* and the *Chalk* are beyond the bounds of the map; but from every part of the district (excepting in the valley of the Thames) the long Berkshire

range of Chalk-hills is a prominent feature bounding the southern horizon (highest elevation, 893 feet).

"Much of the district is covered with gravels: the Low Level Gravel, chiefly in the valleys (on the brink of this gravel Oxford is built), and the High Level Gravels, on the top of one or two hills."

Four horizontal sections were given, as follows:—

"The *first* Horizontal Section starts from the turn to Marston, about one mile due east from centre of Oxford (Carfax).

"The surface of the clay at this point is 186 feet above sea-level. Oxford is built on a bed of (Low Level) gravel; the highest point being at Carfax, viz., 216 feet above sea-level. Taking the St. Clement's level as that of the average of the clay, the gravel appears to attain a maximum thickness of 30 feet; and that is the usual depth of the wells in the higher parts of Oxford. The main Headington Road runs due east; but a lane turns off, in a south-easterly direction, towards Shotover, just at the junction of the Oxford Clay with the Calcareous Grit.

"The section mainly follows this road. A quarry can be seen of Coral Rag, resting on the sands of the Lower Calcareous Grit; and further up, of the Kimeridge Clay, resting on the Coral Rag. Still further, the Portland Sands are seen, resting on the Kimeridge Clay; and in the large pit on the left the Iron Sands to all appearance are seen capping the Portland.

"The *Second* Section, across Shotover Hill, and a considerable extension of high land eastward, is taken from the Geological Survey.

"It shows the *outlying* character of the Iron Sands, which for this reason have been associated with the ordinary Lower Greensands, occurring some few miles to the south, and in direct relation with Gault, Upper Greensand, and Chalk.

"The *Third* Section (also following the Survey) is one across the Cumnor Hill, drawn in the same direction. The lithological character of the sands is somewhat different; and it will be observed they rest directly on the Kimeridge Clay. On Shotover they rest on the Portland Sands.

"The *Fourth* Section is one across a portion of the Coralline Oolite ridge, which divides the Thames Valley from that of the Ock. It does not rise to any great height.

"The height of the meadows on the bank of the Thames, in a line with the section, is 207 feet above sea-level; those on the bank of the Ock 192 feet. The highest point in this part of the ridge is on the main road, where the surface is 268 feet. The distance between the Thames and Ock at this point is a little over

three miles, so that the rise of some 60 feet over so large an extent is scarcely perceptible. The section therefore exhibits the very level character of the beds."

The region traversed by the first two sections was visited on the afternoon of the first day; the third and fourth sections on the second day.

The following is the vertical section in the direction of Shotover, according to Mr. Parker, omitting the Lower Calcareous Grit and Oxford Clay.

	Feet.
Iron Sands, with geodic concretions of Ironstone. Laminæ of white and coloured clays. Fresh-water Shells	60
Portland Sands, with large spheroidal concretions and irregular bands of Limestone	60
Kimeridge Clay—A bed of calcareous concretions near the base	70
Coral Rag. The top bed in some places is Oolitic and worked for Freestone. Elsewhere raggy and coralline	30

Since the visit of the Association in 1874 the evidence as to the development of the Oxford Clay and underlying beds in the immediate vicinity of the city has been carefully sifted by Prof. Prestwich, from data supplied by the boring for coal at Wytham, in 1829, and by a boring at St. Clement's for water a few years later. For reasons which it is difficult to understand, the late Prof. Phillips assigned to the Oxford Clay here the excessive thickness of 600 feet, but Prof. Prestwich has shown that its thickness at St. Clement's, according to his interpretation of the strata passed through in the bore-hole, is 263 feet, underlaid by a considerable thickness of Bathonian beds, as might be expected from their great development in the Woodstock country. The saline character of the water obtained from the bore-holes at St. Clement's induces the suspicion that possibly the Trias was reached at the moderate depth of 420 feet. The clay-pits at St. Clement's are in the upper part of the Oxford Clay of this district, and many specimens of *Ammonites vertebralis* and *Gryphæa dilatata* were noted.

Proceeding along Cowley Marsh the party ascended the slope of the Lower Calcareous Grit sands, which may sometimes be seen resting directly on the Oxford Clay. On the top of the plateau (Bullingdon Green) are numerous Coral Rag pits. The vertical sections here seem barely to attain 26 feet. The highest

beds of all consist of true Coral Rag, full of the prostrate branches of *Thecosmilia*, and with tabular lines of *Thamnastræa* and *Isastræa*. Mammillated urchins, as *Cidaris florigemma* and *Hemicidaris intermedia*, are not uncommon. Opinions differ as to whether this rubbly rag represents a reef *in situ* or a drift accumulation. The late Prof. Phillips inclined towards the latter view. This Rag rests upon a hard crystalline limestone series, which, in this neighbourhood, is divided by a sort of soft oolitic grit and sand, but this division can barely be recognized at Headington. The limestone series rests upon the loose sand of the Lower Calcareous Grit. There is a profusion of fine shells in these hard limestones, a monomyarian fauna somewhat prevailing. *Lima rigida* and *L. læviuscula* are common and conspicuous.

Northwards, at the old Windmill Pits, the Coral Rag may be observed under somewhat different conditions, and further up the hill the junction with the Kimeridge Clay is seen, but the quarry is now disused, and this very interesting section is not so fresh in consequence. One specimen of *Rhynchonella inconstans* was secured from the Clay, and higher up a few small bad specimens of *Exogyra virgula*. Remains of large Saurians are found from time to time. The Clay is succeeded by the Portland Beds, here consisting for the most part of sands and irregular limestone bands and concretions, in which were noted *Trigonia gibbosa*, *Cardium dissimile*, &c., &c.

The Portland Beds are here succeeded by the often discussed Shotover Iron Sands, sometimes grouped as Wealden. At this spot they are not rich in fossils, but towards Wheatley (about a mile to the south) beds of *Unio*, *Cyrena*, and *Paludina* are found.

Descending the hill, the Coral Rag was again inspected in the Headington quarries (see general section at Shotover *supra*).

The following is a careful and detailed section of the Headington Quarries by Prof. J. F. Blake :—*

	Ft.	In.
1. False-bedded comminuted Shell Limestone .	16	0
2. Irregular Coral Rag with *Thecosmiliæ* passing into and alternating with the beds above .	12	0
3. Semi-oolite Shell-bed with *Cid. florigemma* .	7	0
4. Pebbly bed and layers of nodules with *Am. cordatus*	0	8
5. Sands of the Lower Calcareous Grit		

* Blake and Hudleston, "Corallian Rocks of England," Quart. Journ. Geol. Soc., vol. xxxiii., 1877, p. 309.

In this section No. 2 represents the Coral Rag passing upwards into a building-stone (such as has been much used at Oxford in former years); whilst it rests upon a hard-bedded semi-oolitic limestone, No. 3, full of large shells, as *Ammonites plicatilis*, *Phasianella striata*, *Natica clytia*, *Astarte ovata*, *Gervillia aviculoides*, *Perna mytiloides*, *Corbicella lævis*, *Myoconcha Sæmanni*, *Lima lævisculpta*, *Pecten lens*, *P. vimineus*, and spines of *Cidaris florigemma*.

In the evening Mr. Parker exhibited a collection of the fossils of the neighbourhood, principally from the Oxford Clay, Lower Calcareous Grit, Coral Rag, and Kimeridge Clay.

On the following day the party left in carriages for Cumnor, $3\frac{1}{2}$ m. S.W., Fyfield, $7\frac{1}{2}$ m. S.W., and Marcham, 7 m. S.S.W. of Oxford. Near the Cumnor Clump is a pit in the Kimeridge Clay, where the specimen named *Iguanodon Prestwichi* was found.* These remains, according to Mr. Hulke, illustrate nearly every part of the skeleton of an immature individual, which, however, differs materially from the Wealden fossil. Prof. Seeley believed that the differences were important enough to place the animal in a new genus (*Cumnoria*).

The following section of the *Iguanodon*-pit was drawn up by Prof. Prestwich for the use of the party. Beneath a capping of Lower Greensand there comes—

a. Light-coloured and mottled Clay (altered).

b. Grey Clay with numerous small ferro-argillaceous concretions in the upper part—few fossils.

c. Layer of large flat Septaria.

d. Grey Clay, with seams of fossils, *Ammonites*, *Thracia*, &c., *Pliosaurus*.

e. Ditto with *Cardium*, *Trigonia*, &c., Vertebra of *Ichthyosaurus*.

f. Thin ferruginous seam full of *Gryphæa virgula*, a few *Lingulæ*, &c.—*Iguanodon*-bed.

From the top of the hill near the Clump there is a most extensive prospect, bounded at the far south by the Chalk escarpment.

Shortly after regaining the high road the party entered the remarkable stone-pit on Bradley Farm. There is much variety here within a short compass. The highest series is a mass of Coral Rag, here containing, for the most part, a large Mono-

* Quart. Journ. Geol. Soc., vol. xxxvi. p. 433.

myarian fauna, but with bands of the usual urchins. At its base is a white flaggy and shelly limestone, of very slight thickness, but important as occupying a position analogous to that of the great Shell-bed in the Headington district. Beneath this come loose sandy masses, in places even clayey, and then a massive limestone grit, the lower portion containing a profusion of Gasteropoda. This may be regarded as a shell-bed towards the top of the Lower Calcareous Grit, and its contents are rather unusual. *Ammonites vertebralis* is common, *A. perarmatus* less so. There is an abundance of small *Naticæ*, and one or two species of *Nerita* occur, similar to Bathonian forms; also a species of *Amberleya*, very similar to the *A. nodosa* of the Great Oolite. It is, perhaps, the only place in England where *Chemnitzia abbreviata* has been found. To these we must add *Cylindrites Luidi* in great numbers, and several specimens of *Cerithium* and *Nerinæa* usually small. No lack of bivalves accompany these, but the assemblage of small and peculiar univalves is worthy of attention. The loose sands of the Lower Calcareous Grit underlie the bed.

The drive from Cumnor towards Fyfield presents no very marked geological features, but there are some interesting though rather obscure sections in the latter parish, where false-bedding is seen on a very considerable scale.

The members were entertained by Mr. Parker at Fyfield Manor House and afterwards paid a hasty visit to one of the celebrated Marcham quarries, where the Corallian beds are thin and variable, and where the uppermost Limestone (Coral Rag) is often replaced by sandy beds with concretions. Below this group comes the main Shell-bed of this district, here charged with a very large variety of *Trigonia perlata* and other fossils. The lower beds of limestone contain many specimens of *Natica*, but the peculiar fauna of Bradley is no longer found. The bottom of this quarry is very full of water. The great quarry whence so many Lower Calcareous Grit fossils have been obtained was not visited, as the evening was drawing on, and the members were anxious to return to Oxford.

[The latest visit to Oxford was at Whitsuntide, 1890, Prof. A. H. Green being Director.]

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EXCURSION TO BANBURY.—April 14th and 15th, 1873.

Directors—Professor J. Morris, F.G.S., and Thomas Beesley.

(*Report by* T. Beesley.)

(*Proc. Vol.* iii. *p.* 197.)

The first visit was to some clay-pits on the south-west of Banbury, where the *Ammonites capricornus* and *A. margaritatus* beds of the Middle Lias are imperfectly seen. Excavations are rare near the town, and go but little below the surface. Few fossils were noticed. Afterwards a small quarry of Marlstone (*Ammonites spinatus* zone), near the Infirmary, was visited, and a few of the common fossils obtained. The cannon-ball structure of the Marlstone, disclosed by weathering, was noticeable here. The *Ammonites Henleyi* beds were not then exposed.

After luncheon the party took the road towards Oxford in carriages. Turning to the east, after a drive of rather more than two miles over the Marlstone plateau, with here and there patches of Upper Lias, the road gradually falls towards Twyford Wharf, on the Oxford Canal, where an extensive excavation for brick and tile-making shows the *Ammonites margaritatus* beds resting upon the *Ammonites capricornus* marls (Lower Middle Lias). An irregular band of hard siliceous Marlstone, the base of the Marlstone series, occurs here, containing a rather peculiar assemblage of fossils. Above this is a thin bed of sand, and then about

15 feet of sandy marl and shale underlying the Marlstone rock-bed. In this spot, chiefly from the lower marls, and often from nodules, many fossils were got, including *Ammonites margaritatus* and *A. Henleyi* (the latter not previously found so high up), *Belemnites paxillosus* and *B. clavatus*, *Pleurotomaria rotelliformis*, *Cardium truncatum*, *Cypricardia cucullata*, very common here; *Plicatula spinosa*, large and with nacreous interiors; *Modiola scalprum*, *Rhynchonella variabilis*, &c. *Serpulæ* were abundant in the siliceous marlstone. A similar stone which was formerly quarried for road metal at Warkworth, three miles north-east, on the opposite side of the river, afforded many interesting fossils. Bones of *Ichthyosaurus* and coprolites, as well as crustaceans, have been found at Twyford.

Professor Morris directed attention to the fine state of preservation of the *Plicatulæ* and other attached shells, which showed that they had lived and died upon the spot, in a shallow and quiet sea.

Passing over the Cherwell into Northamptonshire, King's Sutton Church, famous for its graceful tower and spire of Perpendicular work of the 15th century, was hastily inspected under the guidance of the Rev. W. Buckley, Rector of Middleton Cheney, and Mr. William Willes, who met the party. King's Sutton Ironstone Quarry, situated three quarters of a mile south of the village, and not far from the Great Western Railway, with which it is connected by a tramway, was next visited. The following is the section:—

	Ft.	In.
Soil, very sandy and ferruginous . . .	2	6
Marlstone, with *Rhynchonella tetrahedra* . .	0	8
Marlstone	2	6
Marlstone, with *Rhynchonella tetrahedra*, *Terebratula punctata*, and *T. resupinata* . .	1	0
Marlstone, with pebble-like concretions . .	1	0
Rusty ferruginous concretions	1	8
Sandy blue marl and grey shale.		

The concretions are highly phosphatic. The iron in the stone averages 23 per cent.

Many rare and interesting fossils have been found in this quarry, chiefly from weathered blocks of the stone; but upon the present occasion few of the latter were to be seen, yet some good things were secured, including a fine mass of coral, apparently a *Septastræa*. Several species of corals have been lately found—rare fossils in the Marlstone.

Returning to King's Sutton the route was by Astrop Wells, a rather fashionable health-resort in the 17th and 18th centuries, up Newbottle Hill, where junctions of the Middle and Upper Lias, and of the latter with the siliceous limestones of the Inferior Oolite (Northampton Sands) were traced, to Newbottle Spinney, where are the remains of large quarries in the Inferior Oolite, and where many Roman remains—coins, pottery, dishes, or *paterœ* of pure tin, have been found. Across the eastern end of this spinney passed the whirlwind of November 30th, 1872; and within it striking remains of the shattered and prostrated trees were still visible. This whirlwind had its origin near the brook at Walton Grounds, about a mile S.S.W. A slender column, looking like smoke or steam, was suddenly shot down from the strongly agitated clouds to the earth. Revolving with great velocity from right to left, it advanced rapidly in a N.N.E. direction, breaking and overturning great trees in its course. After passing the spinney it threw down the wall of Newbottle Park in many places, hurling the stones to the west. Here it was observed to send out flashes or sparks of red light (probably electric discharges) to the ground. At the brook beyond, it made great havoc amongst the trees. After this it became invisible, but was traced by its effects two or three miles further. In a slab of Inferior Oolite limestone from a wall a specimen of the problematical fossil, believed by Dr. Bowerbank and others to be a sponge, and first discovered at Milcomb Hill, on the other side of Banbury, was found. Many specimens had previously been found by Mr. Beesley and Mr. E. A. Walford in the broken-down wall of Newbottle Park. Here Professor Morris gave a very interesting field-lecture on the physical geology of the district, especially explaining the process by which the Lias valleys had been excavated, and pointing out that the Marlstone and Oolite table-lands had been preserved from destruction by the resistance offered by their stony bands.

On the following morning the members passed out of the town in a westerly direction, and their attention was drawn to the fact that they were now upon the Upper Lias, whilst at the top of an adjoining field they could see the general level of the Marlstone 100 feet above them. At the top of the field just mentioned Mr. Beesley pointed out an excavation called the "Bear Garden," which Dr. Stukely and others had described as a Roman Castrensian amphitheatre. It is probably nothing more than an old stone-pit, subsequently adapted for bear and bull-baiting. No Roman remains have been found in or about it. A little further the

Marlstone was seen cropping out on the left side of the road, whilst on the right, or lower side, the Upper Lias had been found in well-sinking to be 20 feet thick. Half a mile from Banbury a halt was made at some brickyards, showing the Upper Lias Clay, capped by the Inferior Oolite. Constitution and Crouch Hills, between which they stood, were mainly composed of Upper Lias; but the former, let down by the fault already noticed, and by a still larger one, marked on the Survey map (running from Hardwick on the north-east to Broughton on the west, and producing a displacement of 100 feet), showed also Inferior Oolite, capped by the lower beds of the Great Oolite. Fossils were abundant in the latter, especially *Terebratula maxillata*, *Rhynchonella concinna*, *Ostrea Sowerbyi*, *Echinobrissus clunicularis*, *Clypeus Ploti*; but the pits were now filled in. At Bretch, a little beyond, Marlstone was seen rising above the Upper Lias, and much tilted to the south. Here a cave in the Marlstone was noticed, evidently having some connection with the fault. It is not likely that it contains fossil bones, or flint implements. Broughton Church—an interesting building of Early 14th Century work, was next visited, and some members took the opportunity of inspecting the Castle, a highly picturesque erection of the 14th, 15th, and 16th centuries, and noted in the early period of the Civil War as the seat of the Puritan leader, Viscount Saye and Sele.

Afterwards the party made their way to the quarry near Broughton Fulling Mill, where the upper beds of the Great Oolite—here let down by a double fault and dipping considerably to the brook on the south—are quarried for lime-burning and road-stone.

Near the top of the quarry the beds are broken by small faults, and are capped in places by some grey slaty layers resembling Forest Marble. It was suggested that any decision as to these should be adjourned until the other neighbouring sections had been seen. One or two corals and a few other fossils were found here. It was the opinion of Professor Morris that the inclined position of the beds was due to a roll rather than a fault.

Passing the brook and ascending the opposite hill, another Great Oolite quarry, called in Mr. Beesley's paper on the Geology of Banbury the Tadmarton Lime-kiln Pit, was soon reached. This, as evidenced by fossils, showed the lower, but not quite the lowest beds.

Many fossils were secured, including a small crustacean

(Glyphea rostrata), *Pholadomya Heraulti* and *P. socialis*, *Cypricardia bathonica*, *Modiola cuneata*, *Thracia*, *Astarte*, *Leda*, *Cyprina Loweana*, *Ceromya undulata* and *C. bajociana*, *Eulima communis*, *Cylindrites*, *Natica*, *Terebratula maxillata* and *T. perovalis*, *Echinobrissus clunicularis*, *Clypeus Mülleri?* *Acrosalenia*, &c.

A quarter of a mile to the south is another quarry, the Tadmarton Forest Marble Pit. It shows the grey shelly and slaty beds previously mentioned still more distinctly than the Fulling Mill Pit. These beds are coloured as Forest Marble on the Survey map; but some geologists have been inclined to think them shelly beds, similar to those of the Forest Marble, intercalated in the ordinary Great Oolite series. Upon the present occasion, however, the question was decided in favour of the view taken by the Geological Survey; for on approaching the quarry from the N.E. many fossils were picked up from the surface of the ploughed field, which Professor Morris and others at once identified as belonging to the Cornbrash *(Avicula echinata*, *Terebratula obovata*, *Anabacia orbulites)*.

The Oolite of this quarry is hard and compact, often blue within. From it were obtained the fine series of bones of *Teleosaurus brevidens* and *T. subulidens* of Phillips, as well as a paddle-bone of an *Enaliosaurian*, and a few small bones, doubtfully referred to *Rhamphorhynchus* in Mr. Beesley's collection. *Ostrea* and *Gervillia* are abundant in the clay below the Forest Marble; but the ordinary Great Oolite fossils are scarce here.

Tadmarton Heath, 340 feet above the Cherwell, and 680 feet above the sea, covered by the loose sands of the Inferior Oolite (white, yellow, and red) was next sought. Here rises the Holywell brook, an affluent of the Cherwell, and finally of the Thames; as well as the Stour, whose waters flow westward, to mingle with the Warwickshire Avon and the Severn. On the summit of the heath is a fine circular British camp, with a quadrilateral outwork guarding the entrance on the east. From it a paved way led to the very copious and pure Holywell Spring, and many Roman coins and other remains have been found about it. Two tumuli stand about 400 yards to the north-west, and the square camp of Hook Norton is distant three-quarters of a mile west-south-west; whilst the camp of Madmarston and the site of the Romano-British settlements below it are seen two miles off on the north.

Milcomb Hill on the east, showing the junction of the Inferior Oolite and Upper Lias, was then descended; a few Inferior Oolite fossils were got from some broken stone on the roadside, and some crystals of *Selenite* were collected from the Upper Lias clay. A short stay was made at Bloxham to give the party an opportunity of examining the church, with its magnificent tower and spire of the 14th century (of exquisite design and proportion, and 195 feet in height), and its "decorated" windows and doorways.

Combe Hill, Barford, was the next halting-place. Here the Inferior Oolite rock-bed, first detected by Mr. Beesley, is let down by two parallel faults, half-a-mile apart, between which the river Swere runs eastward to join the Cherwell. The rock is thick-bedded, with partings of marl or sand, oolitic, shelly, or compact, and nearly white. It dips to the south. Its exact position is not quite made out, but it is probably low down in the series. The resemblance to the Bastard Freestone was noticed. Its fossils, which are numerous, generally differ from those of the so-called Northampton Sands, to which the yellow-brown sandy flags and limestones of Milcomb Hill and Newbottle are referred.

Many species were collected, including *Nautilus Baberi*, *Belemnites* sp., *Natica cincta* (*leckhamptonensis*), a large *Pleurotomaria*, *Trigonia Beesleyana* (Lycett), *Perna quadrata*, *Lima grandis*, *L. pectiniformis*, *L. cardioides*, *Pecten lens*, *Hinnites abjectus*, *Terebratula submaxillata*, *T. perovalis*, and *Thamnastræa Defranciana*. At Blackingrove, on the other side of the river, the same beds were quarried, even in Roman times; and from these the late Mr. C. Faulkner, of Deddington, had two or three species of ammonites, *Pholadomya fidicula*, *Pygaster semisulcatus*, and other Inferior Oolite forms. Mr. Beesley has more than fifty species from the two localities, most of which are exclusively Inferior Oolite fossils.

On the return, a view was obtained of Adderbury Church, thus adding the last of the three fine churches of the neighbourhood to the visitors' list. The extensive ironstone quarries east of Adderbury were next examined. These show eleven or twelve feet of Marlstone in two or three beds, capped by three or four feet of Upper Lias (Cephalopoda-beds and whitish clays). The Marlstone beds show many vertical fissures filled with Upper Lias, and are a little shifted and tilted, "so as to make frequent parallel waves about a foot high." The stone is in large blocks

brown on the exterior, bluish-green within, where it has an oolitic appearance from the presence of lenticular grains of ferrous silicate. The two Rhynchonella-beds are well marked; and the thin top bed, forming a transition to the Upper Lias, contains ammonites of Upper Lias type, and many fine gasteropods. The ferruginous Marlstone here contains from 18 to 24 per cent. of iron. Below the Marlstone, and separated by three feet of shale, is a bed of grey shelly limestone; and below this a rusty concretionary bed.

After the section had been explained by Mr. Beesley, and a little time had been spent in its examination, the members drove home to Banbury.

EXCURSION TO CHIPPING NORTON.*

APRIL 22ND AND 23RD, 1878.

Directors—THOMAS BEESLEY and W. H. HUDLESTON, F.R.S.

(*Report by* W. H. HUDLESTON.)

(*Proc. Vol.* v. *p.* 378.)

EARLY in the afternoon of Easter Monday the party from London met the two Directors at the Chipping Norton Railway Station. Their numbers were swelled by a reinforcement of the local geologists, amongst whom were Mr. E. A. Walford, of Banbury, and Mr. James Windoes, of Chipping Norton, whose collections, together with that of Mr. Beesley, have thrown so much light on the palæontology of the district.

An unfinished tunnel, intended to pass through a spur of the massive hill, on the upper slopes of which the town of Chipping Norton is built, was the first object noted along the new line. The waste heaps of clay around the shafts attracted the attention of members as the party ascended from the low ground, and several good fossils, chiefly from the *Am. capricornus* and *Am. margaritatus* beds, were secured. The quantity of *Cypricardia intermedia* is noteworthy; the shells sometimes come out of the rock in the most perfect condition, like a nut out of a husk. Mr. Beesley's list of the fossils from the above zones attests the richness of the Middle Lias in this locality, and the care with which it has been worked. ("Proc. Geol. Assoc." vol. v. p. 182).

* See also Papers by E. A. Walford, Quart. Journ. Geol. Soc., vol. xxxix. p. 224, and vol. xli. p. 35.

The sections leading up to the tunnel were partly grassed over, and the sequence from the *capricornus* clays through the *margaritatus* and *spinatus*-beds into the blue clays of the Upper Lias and thence into a rubble of *Clypeus*-grit was not very clear. The Upper Lias is said to have a thickness of some 35 feet hereabouts.

There is a commanding view from the top of the hill overlying the tunnel, especially in a north-westerly direction, over the Oolitic outliers of the Cotteswolds, and here Mr. Beesley gave some account of the physiography of the district through which the line is carried in the direction of Hook Norton. On the northern horizon is Bright Hill, famous for the Rolwright Stones, concerning whose origin archæologists generally have much to say. The ridge on which they stand is interesting as forming the watershed between the Thames and Severn basins; and the stones have this peculiarity, that those who count them never arrive at the same conclusion as to their number.

A walk of a mile or so along the line brought the party to the cutting at Langton Bridge, where one of the most interesting sections afforded by the new railway was seen. It will readily be understood by those who take an interest in Oolitic geology that the region where the S.W. or Cotteswold type of Lower Oolites passes into the N.E. or Northamptonshire type is one worthy of close attention. Probably no better section for showing the junction between the Inferior Oolite (Bajocian) and Great Oolite (Bathonian) had been exposed in North Oxfordshire than this one at Langton Bridge. Yet, owing to the high angle at which the beds dip towards the N.E., and the constant tendency to slip, together with other causes, the sequence is by no means easy to read, and is fruitful of divergent opinion; the Rolwright glamour reigns in the valley as well as on the hill.

Unfortunately this is just one of those places where one misses seeing a great deal. Probably about 20 feet of Inferior Oolite beds are exposed, but no *Clypeus*-grit, if indeed the real *Clypeus*-grit extends as far; anyhow the base is not visible, as the cutting does not extend down to the Upper Lias. The character of the Inferior Oolite is most changeable and deceptive, but is typical of that which exists in this immediate district on both sides of the great fault, and may be described as consisting of pale fawn-coloured gritty limestones, partly oolitic, with variable proportions of sand and iron, which produce the most chameleon-like effects within short distances, and lend themselves readily to those who are disposed to doubt the identity of anything. Casts

of univalves have been noted, and a full-sized *Holectypus depressus* was found, but it may be said with truth that recognisable fossils are very rare. This sort of Inferior Oolite certainly must occupy a very high position in the series, being always above the *Clypeus*-grit, where that phase of the Inferior Oolite obtains; and we shall see presently that the *Clypeus*-grit of Chipping Norton is well within the *Parkinsoni* zone. In the district, therefore, round Chipping Norton, extending probably as far as Langton Bridge, the lower zones of the Inferior Oolite are absent, and the term "Northampton Sand," as applied to such beds, seems inappropriate, the real Northampton Sand being confined to the zones of *A. Murchisonæ* and *A. opalinus*.*

Avoiding all stratigraphical, and, as much as possible, all minor details, the following is a summarised section; the thicknesses, &c., would vary within short distances:

LANGTON BRIDGE (LINE 550 FEET ABOVE SEA-LEVEL.)

		Ft.	Ft.
A	Limestones (sometimes flaggy) and grey Marls—*Ostrea Sowerbyi* and *Rhynchonella concinna*	50	
	Flaggy Limestones	11	
	Rubbly Limestones and Marly Clays, with *Cypricardia* (small), *Ostrea Sowerbyi*, *Rynchonella concinna*, varieties of *Terebratula*, and large *Clypeus*	4	
	Limestones with *Rhynchonella* in the upper bed	4—69	
B	Grey Marl with *Ostrea Sowerbyi*	2	—
	Black Clay with ochreous shelly lumps, apparently fragments of Oysters	3	
	Sticky marly Clay with small *Ostrea*, &c.	2— 7	
	Loose Red Sand in places derived from the decomposition of—		—
C	Inferior Oolite Limestone, previously described, base not seen	20	

Whatever names may be given by geologists to the peculiar argillaceous series, B, its total contrast to the sandy limestones of the Inferior Oolite is complete, and it seems to constitute a fitting introduction to the thoroughly Bathonian group of beds which succeed. Those who derive their impressions from Northamptonshire may fancy they see in it the equivalent of the Upper Estuarine Beds, but they should at least remember that in this section 70 feet of Marls and Limestones belonging to the Lower Division of the Great Oolite (Bathonian) succeed, being doubtless

* Sharp, "Oolites of Northamptonshire," Quart. Journ. Geol. Soc., vol. xxix. p. 285.

the equivalents in a great measure of the Stonesfield Slate. It must not be forgotten on the other hand what an enormous thickness of partly argillaceous beds, known as Fuller's Earth, are interposed in the S.W., between the Great and Inferior Oolites—beds which are 150 feet thick at Bath, 70 feet thick at Minchinhampton, and yet are reported as having entirely disappeared some twelve miles short of this spot. Avoiding for the present the subject of correlation and nomenclature, we see here two extensive groups of limestone, the lower one for the most part gritty and unfossiliferous, of a pale fawn-colour; the upper one grey, clayey, and full of beds crammed with *Ostrea*, *Rhynchonella*, &c. They are divided by a peculiar black clay, which seems almost unconformable to the underlying beds.

On emerging from the cutting the whole series is lost sight of, and the line crosses the bottom of the valley to the other side of Rolwright Ford (Limekiln Farm): thus the continuity of the section is broken, and when resumed much higher beds are reached.

This further portion of the line being reserved for the following day, the party took to the road, where they inspected a fossiliferous quarry in the Bathonian series. The bed here exposed has a strong northerly dip, and, like the one so well known at Enslow Bridge, is remarkable for the abundance and size of *Terebratula maxillata*. It is considered by Mr. Beesley to represent the junction of the typical Great Oolite with the lower zone. A walk through the picturesque village of Over Norton to the town of Chipping Norton completed the day's work. In the evening Mr. J. Windoes exhibited a portion of his collection.

Notwithstanding the ample illustration which the Oolitic geology of Oxfordshire has received at the hands of numerous writers, the immediate neighbourhood of Chipping Norton has been wonderfully neglected. Prof. Judd* observes that "as we pass northwards and westwards into Oxfordshire the Ragstone division of the Inferior Oolite no longer presents its well-marked sub-divisions, but, as shown by Mr. Hull,† is represented only by the *Clypeus*-grit, which, becoming more and more reduced in thickness, finally disappears near Chipping Norton." Near the banks of the Windrush, some ten miles S.W. of Chipping Norton, "about 15 feet of rock is exhibited, of an exceedingly cross-

* "Introductory Essay to the Geology of Rutland," p. 11.

† "Geology of Cheltenham," p. 46, *et seq.*

grained Oolite, in which were noticed *Clypeus Ploti*, *Terebratula globata*, and *Lima gibbosa*. It is capped by the shelly freestone of the Great Oolite, without the intervention of the Fuller's Earth, which has altogether disappeared." Eight miles nearer Chipping Norton we again* hear of this *Clypeus*-grit at Churchill, "where there are several quarries in which the rock is very fossiliferous." The outcrop of the Inferior Oolite thence continues northward, "and winds round by Chipping Norton till it abuts against a fault near Coll's Combe Barn."†

This part of the story is intelligible enough, but when we turn to the Geological Survey Map, Sheet 45, N.W., it will be remarked that the division between Bathonian and Bajocian is not very easy to trace hereabouts. On this point Professor Judd observes "It has been found impracticable in this district to draw a line of boundary between the representatives of the Great and Inferior Oolite. Thus it has arisen that under the term 'Northampton Sand' is included, in North Oxfordshire, the whole mass of variable sandy strata (passing at some points into imperfect ironstones, and at others into impure limestones), which intervene between the Upper Lias Clay and the marly limestones of the Upper Zone of the Great Oolite."

Such an essentially provisional arrangement may suit in some places, but at Chipping Norton it is certainly liable to mislead, as we have the conventional namesake of the true Northampton Sand, which at Northampton comprises the zones of *A. Murchisonæ* and *A. opalinus*, superposed on the *Clypeus*-grit, or *A. Parkinsoni* zone—in other words, the Inferior Oolite is turned upside down.

To ascertain, if possible, how far these matters are capable of further elucidation was one of the objects of the excursion to Chipping Norton.

The town is situated towards the top of the western slope of a hill of Jurassic rocks, separated from the main range of the Cotteswolds by the Vale of Moreton. A benchmark on the Three Tuns Inn, near the northern end of the main street, is 658 feet above sea-level, and this may be taken as the general level of the principal part of the town, the summit of the plateau above, on the Banbury Road, attaining an altitude of about 740 feet. Like so many other places, its position has been determined by a copious

* Hull—"Country about Woodstock" (Sheet 45, S.W.), p. 13.

† Green, in Memoir to Sheet 45, p. 9.

spring, which issues from the hill-side at the junction of the Upper Lias Clay with the Inferior Oolite (*Clypeus*-grit). The position of this spring is about 20 feet immediately below the aforementioned Three Tuns in that part of the town known as "Tite End."

From this point to the *Cetiosaurus* quarry at the top of the hill, in a direction nearly due E., is a rise of between 70 and 80 feet. The *Clypeus*-grit forms the lower part of this rise, and that rock which we may term the Chipping Norton Limestone constitutes the rest, making no allowance for dip. Fortunately a well, nearly on a level with the quarry, supplies us with a means of checking these measurements. It is 55 feet deep, so that we shall not be far wrong in assigning 60 feet as the thickness of the beds between the Upper Lias and the band of Blue Clay in the *Cetiosaurus* quarry, presently to be mentioned. During the visit of the Association there was no exposure of the *Clypeus*-grit, nor any means of noting its junction with the overlying beds. The following are some of the fossils Mr. Windoes has obtained from it:—*Ammonites Parkinsoni*, *Homomya gibbosa*, *Pholadomya Heraulti*, *Ph. Dewalquei*, *Cardium citrinoidum*, *C. lævigatum*, *Trigonia costata*, *T. signata*, *Lima duplicata*, *Pecten*, several small forms, *Terebratula globata*, *Terebratula* sp., *Rhynchonella concinna*, *R. angulata*, *Holectypus depressus*, *Clypeus Ploti*, *Anabacia orbulites*, *An. hemisphærica*, *Montlivaltia trochoides*, and one or two fossils which may be new. This group of fossils points to a very high part of the Inferior Oolite, almost to the *Pholadomya*-grit of Dr. Lycett.

The overlying limestone must, therefore, be very high indeed. Few fossils have been obtained from it at Chipping Norton, there being no exposures of the lower beds which, almost alone, appear fossiliferous. In the neighbourhood of the Priory Farm, however, rather over a mile E.N.E. of the *Cetiosaurus* quarry, the sandy limestone which there overlies the *Clypeus*-grit has yielded abundance of *Trigonia signata*, together with a very variable Oyster, and the same *Trigonia* may be found at one or two other quarries. The form of the shell differs somewhat from the one in the *Perna*-bed at Cold Comfort (Cheltenham).

Reverting now to the *Cetiosaurus* quarry, particular attention was paid to this section. The surface is about 715 feet above sea-level, and is believed to be about 60 feet above the Upper Lias immediately beneath it; the quarry has a face of some 20 feet.

Cetiosaurus Quarry, Chipping Norton.

		Ft.
A	Oolitic limestone, denser than the lower series (C), with *Ostrea*, *Pecten*, &c. Just a fragment at the top of the section	1 — 3
B	The argillaceous series: the upper part sometimes a grey marl, with *Ost. Sowerbyi*, the middle a dense blue clay, shaly in places, with bones of *Cetiosaurus*; the base variable	about 3
		Ft.
	Variable layer of loose reddish sand.	
C	Oolitic limestone of a different character to A: rolled spines of *Acrosalenia*, fish teeth, &c., but poor in fossils. The top beds of the Chipping Norton Limestone	1

Here there is a definite plane and a thorough physical break, and this may be of use ultimately in fixing the boundaries of the Inferior and Great Oolite. In the Argillaceous series, B, we may have the representative of the Black Clay of Langton Bridge, about two miles distant. The irregular abundance of grey marl, with *Ostrea Sowerbyi* above the Clay, favours the view, but, as nearly the whole of the Upper Limestone series, A, has been removed at the *Cetiosaurus* quarry, the section is incomplete in this direction. It is probable that in C of this quarry we have rather higher beds than in C at Langton Bridge, the argillaceous series being transgressive over different beds of the Inferior Oolite.

About a mile from the turnpike on the high road due south of Chipping Norton are two quarries, which seem to afford a further clue. A section, constructed from the two combined, shows the following sequence:—

Quarries on Chadlington Down.

South Quarry.

		Ft.
A	Beds of limestone with *Cardium Stricklandi*, *Lima cardiiformis*, *Ostrea Sowerbyi*, *Rhynch. concinna*, &c., down to a water line (well)	22

North Quarry.

B	Limestone rubble and marl, with a few *Ostrea Sowerbyi*, band of Blue Clay. Lower marly rubble, with small univalves, jaws of *Cidaris*, spines of *Acrosalenia*, plates of Starfish, &c.—say	3
C	False-bedded flaggy oolites, with few fossils to floor of quarry—say	7

Thus at three different points, at Langton Bridge, at Chipping

Norton, and on Chadlington Down, we have two calcareous systems separated by a peculiar layer of Clay and Marl. It may be doubted whether this dividing Clay can be exactly referred either to the Upper Estuarine or to the Fuller's Earth. The beds of this region have a type of their own, and it is no use trying to force them to agree with those of other districts.

Reverting now to the new line, the party proceeded to the Limekiln Farm, where the railway was left on the previous evening, and, in so doing, descended the steep hill into this curiously vaulted valley. At the Cross Roads (surface of road 686 feet) there is a cutting in the so-called *Clypeus*-grit, where, according to Mr. Windoes, the fossils of this horizon occur, but the matrix is not rubbly, the lithology being more that of the sandy and occasionally ferruginous limestone. The blue clay beneath is marked in the map as Upper Lias, and this is exposed further down the hill, but is without visible fossils. After vain attempts to find anything, Mr. Beesley started the theory that it was not Upper Lias at all, but one of the Estuarine Beds. One party contended for the Blue Clay of the Langton Bridge section, and another for the Clays of the Forest Marble, so well seen at the Pest House Cutting. The matter was not settled at the time, but subsequent investigation has shown that the Surveyor was perfectly right in mapping it as Upper Lias.*

Whilst the Langton Bridge Cutting, visited on the previous evening, shows the lower zone of the Great Oolite resting upon the Inferior Oolite, the sections east of the Limekiln Farm seem wholly in the upper division of the Great Oolite. The portion exposed commences with creamy limestones, containing corals, remains of fish and saurians, and a tolerable abundance of other fossils. The base of the upper division of the Great Oolite is hardly seen, but the sequence upwards is complete. Above the creamy limestones is another argillaceous series, then some limestone bands overlaid by a mass of blue marly shale, the whole being capped by a thin and rather poor representative of the Cornbrash. One of the limestone bands, west of the Pest House Bridge, known as the *angulata* bed, from the abundance of *Astarte angulata*, is a complete museum, many of the fossils being characteristic of the Forest Marble of South Oxfordshire, &c. For full list consult Beesley (Proc. Geol. Assoc., vol. v. p. 165). This

* Mr. Walford found foraminifera, spines of urchins, &c., not unlike those of the Upper Lias of Chipping Norton; and Mr. Parker actually found the Marlstone beneath the Blue Clay, just as indicated on the map.

section corresponds fairly with the classic one at Kirklington (Hull, "Country Round Woodstock," Sheet 45 S W., p. 20), and although the Geological Survey differed from the late Professor Phillips as to fixing the line between the Forest Marble and the Great Oolite Limestone, this by no means detracts from the general similarity of the sequence.

The line attains its highest geological position with the Cornbrash of the Pest House Cutting; eastward of this for some distance are small excavations at intervals disclosing portions of the Forest Marble series,* sometimes crammed with oysters. Further east, again, is a bed of Great Oolite Limestone; a band of coral (*Thamnastræa Lyelli* principally) occurs in it.

A short embankment and wooden viaduct lead to a cutting at Duckpool Farm on the south side of Hook Norton Hill, where there is an interesting and much-debated section exposing the northern bounding fault of this longitudinal patch of Bathonian rocks.† In spite, however, of the stratigraphical interest attaching to a fault, Oolitic geologists would willingly have dispensed with a phenomenon which conceals the junction between the Inferior Oolite and the Great Oolite, and thus prevents proper comparison with the section at Langton Bridge. The difficulty of interpretation is further increased by a small subordinate fault on the southern side, and also by the slipping of the beds so as to conceal the hade of the main fault. What we really have, then, is the Upper Lias surmounted by the Inferior Oolite (Hook Norton type), on the north faulted against a variable mass of Bathonian rocks, consisting of Marls with *Ostrea Sowerbyi* and bands of hard stone in places, succeeded by greenish or olive-coloured sands and clays, and the whole surmounted by a fragmentary line of limestone with *Nerinæa*, &c., probably representing the base of the Great Oolite Limestone (upper division). With the exception of this thin cap of limestone, the whole of the beds on the southern side of the fault, about fifteen feet thick, may be referred

* In Northamptonshire and Rutland what are called the Clays of the Great Oolite represent to a certain extent this group.

† These marked stratigraphical features long ago attracted the attention of Conybeare and Philips, who say that "In the valley, however, between Swerford and Great Rolwright they [Oolites] are thrown down by a considerable subsidence, pitching in a steep angle towards its bottom, which they cross close to the entrance of Swerford park; and lying here, as in a hollow trough, again rise towards Great Rolwright." "Geology of England and Wales," 1822, p. 221.

FIG. 90.—SECTION OF BANBURY AND CHELTENHAM DIRECT RAILWAY FROM HOOK NORTON TO CHIPPING NORTON.

1. Cornbrash. 2. Forest Marble. 3. Great Oolite. 4. Upper Estuarine. 5. Stonesfield Slate (?) 6. Upper Inferior Oolite. 7. Lower Inferior-Oolite. 8. Upper Lias. 9. Middle Lias (*spinatus*). 10. Ditto (*margaritatus*). 11. Ditto (*capricornus*).

FIG. 91.—SECTION SOUTH-EAST SIDE OF CUTTING, NEAR HOOK NORTON.

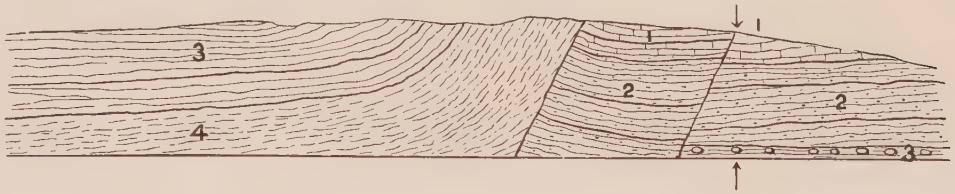

FIG. 92.—SECTION NORTH-WEST SIDE OF CUTTING, NEAR HOOK NORTON.

1. Great Oolite. 2. Upper Estuarine. 3. Inferior Oolite. 4. Upper Lias.

to the lower division of the Great Oolite. At present, therefore, the section is so far incomplete that we cannot feel sure of seeing the top of the Inferior Oolite on the northern side of the fault, nor yet the base of the lower division of the Great Oolite on the south. Should the lower division of the Great Oolite system be as thick here as at Langton Bridge (70-80 feet), the amount of throw must be very considerable.

The thickness of the Upper Lias at Hook Norton is estimated by Mr. Beesley at from thirty to forty feet (with *Ammonites bifrons*, *communis*, *fibulatus*, and *opalinus*), and above this come the sandy thick-bedded limestones of the Inferior Oolite, belonging to a different zone from that at Langton Bridge, and containing a number of fossils (see Mr. Beesley's list, *loc. cit.*). The hill is not pierced, but there are two extensive cuttings on either side. The one on the north showed a deep section, quickly exchanged for an equally lofty embankment, where the line debouches upon the broad Hook Norton valley. Mr. Beesley considers that the Inferior Oolite of Hook Norton is in the *Murchisonæ* zone; but as the term *Murchisonæ* is applied to so many ammonites, it is generic rather than specific in its application. The characteristic ammonite here is not by any means the *A. corrugatus* of the *Murchisonæ* zone of Cheltenham, but a very discoidal ammonite, one of the smooth and compressed forms which might go under the general designation of *læviusculus*.

The conditions which produced this sandy limestone seem to have been favourable to *Trigonia*, as several species are quoted from here. A very remarkable group of the *Undulatæ*, which may be referred generally to the *T. producta* of Lycett, but which also has affinities with *T. literata*, Y. & B., and with *T. quinquecostata*, Lyc., is another proof how local are the forms of this genus—so abundant in the shallow waters of the Jurassic period—and how difficult it is to find names for them all.

At the village of Hook Norton the excursion came to a close.

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Maps.—Ordnance Survey. Geological. Sheet 44. 8*s.* 6*d.*
Quarter-sheets, 45 S.W., N.W. 3*s.* each.
New Ordnance Survey. Sheets 218, 236. 1*s.* each.

Books.—Same as for Oxford (see p. 250).

T. Beesley, On the Geology of the Eastern Portion of the Banbury and Cheltenham Direct Railway. Proc. Geol. Assoc., vol. v., 1877, p. 165.

BERKSHIRE.

EXCURSION TO READING—3RD JUNE, 1876.

Director—Prof. T. RUPERT JONES, F.R.S.

(*Report by* W. H. HUDLESTON, F.R.S.)

(*Proc. Vol.* iv. *p.* 519.)

THE particular group of sands and clays which immediately overlie the Chalk of this district has received the name of the Woolwich and Reading beds, from the fact of its being largely developed, and also, what is quite as important, perhaps, largely worked for economic purposes, in the neighbourhood of those two towns. These beds represent a low, though not quite the lowest, group of English Tertiary formations, and as there are no Tertiary beds at Reading itself lower in the series, they are, in this area, the base of the London Tertiaries. In this neighbourhood organic remains are scanty, scarcely any shells but oysters being found, and these mostly confined to one bed. In this respect the Reading representatives of the group differ considerably from the beds at Woolwich referred to the same geological horizon (see Reports of Excursions to Woolwich).

The party proceeded to Katesgrove Pit, on the further side of the Kennet, where the Messrs. Poulton kindly admitted members to inspect this large excavation, which has been opened for at least 100 years. After a discussion as to the origin of the name, which Mr. Albery had reason to believe was originally "Cattle's Grove," a very curious *amphora* was shown to the party. Mr. Poulton pointed out where the Roman relics were found on Bob's Mount, and the Director then led the way into the body of the excavation, which presents a fine section of the Reading beds, somewhat impaired by landslips, but yet exhibiting, in most striking contrast, the deep purple of the mottled clays and the very pale buff of the underlying sands. A portion of the very base of the London Clay may be observed in one part of the section, succeeded by a variable deposit made up of re-arranged drift and sand, with occasional quartzites, the whole being covered by an ancient soil full of split flints. Captain Cooper King soon detected several of artificial origin, in which the bulb of percussion

was well exhibited. Before quitting this pit the Director drew attention to the singular effects which may be noted in a pool, having a clayey bottom, in process of drying-up. In the first place he pointed out the tendency of the spaces included between the cracks to assume definite geometrical figures, and secondly, the curious reticulated markings in slight relief which cross these spaces, and which he showed to be due to the mole-like workings of a small beetle, a specimen of which was secured.

A little further on is the Waterloo Pit, where, in the loose white sands, which here constitute the most accessible portion of the Woolwich and Reading beds, two irregular bands of pale laminated clay or loam, generally about two feet apart, were observed, and portions of one, if not both of these, were largely charged with leaves of dicotyledonous plants, notably of species of maple and poplar. These fossil leaves serve in a remarkable degree to establish the correlation between the Woolwich and Reading Beds referred to this group, and are interesting to botanists as one of the earliest instances of *dicotyledonous* plants in the British Islands. Similar leaves have been found fossil in another Reading section by Prestwich.

The party now crossed the valley of the Kennet and proceeded to visit the pits at Coley Hill, both of which were kindly thrown open to their inspection by the proprietors, Messrs. Wheeler and Messrs. Collier. The foreman of Messrs. Wheeler's pit, in anticipation of the visit, had requested the workmen to preserve any objects of interest, and, in consequence, a fine assortment of oyster shells and of sharks' teeth awaited inspection. The base of the formation, not seen in either of the pits hitherto visited, was finely displayed in Wheeler's pit, where a fresh piece had been cut out, exhibiting the entire series down to the Chalk. Here the Chalk is much fissured and perforated to the depth of about 18 inches below its junction with the Woolwich and Reading beds. These fissures are filled in with the material of the Bottom-bed, which consists largely of glauconitic grains, clay, and flint grit; pieces of lydite also occur. The partial decomposition of the iron of the glauconite has discoloured the sides of these fissures, which would seem, from certain appearances noted, to be the result of the roots of marine plants, which, having no loose stones to cling to, must have either forced their supports into the little chinks of the sea bottom, or have been washed away. On this singular surface rests the Bottom-bed, which is a strange mixture of

glauconitic grains, clay, subangular green flints, and small flint chips. Here occur the sharks' teeth and the oyster shells, the latter having a strong resemblance to those of our British seas, although known to palæontologists as *Ostrea bellovacina*. The oysters occur principally in a bed about three feet above the Chalk, but this oyster-bed, though of wide extent, is not proved everywhere throughout the workings on Coley Hill. Above this very curious "Bottom-bed," which seems to be a mixture of almost everything, and is thoroughly marine in its character, occurs a mass of buff-coloured sands with occasional blue shales, containing much carbonaceous matter, the upper portion being variegated buff and grey sands; these are surmounted by bedded clays of various colours in which purple predominates—a formation not known to contain any fossils. It seems to be made up of masses of other clays, all pugged together, and is possibly derived from the destruction of the outcrop of some Secondary clay, as this was slowly raised within the influences of marine denudation during the earth-movements which must have taken place in the area now occupied by the Thames Basin subsequently to the deposition of the Chalk. The top of these clays in Wheeler's pit, instead of being capped by London Clay, as at Katesgrove, has its surface worn into a perfect network of holes and caldrons, which are filled in by the superincumbent gravel and drift. The effect is most curious to the eye, and when one reflects upon the enormous interval of time which this singular plane of erosion represents—an interval of time greater perhaps than that between the top of the Chalk and the base of the series—it must be admitted that a section may be almost as remarkable for what it leaves to the imagination as for what it offers to view. In Collier's pit, on the northern side of Coley Hill, although the same general subdivisions prevail, there is sufficient variety to prove the very irregular character of these so-called estuarine beds. The especial objects of search here were the "clay-galls" which occur in some of the sandy beds, and after some time a considerable number of these remarkable balls of clay was found in the sands. The explanation of the Directors seems a very good one, namely, that during the deposit of this variable series a channel had been cut through a recently formed clay, this hollow being flanked by little cliffs of the eroded clay. Sand was subsequently deposited in the channel and pieces of clay falling out of the little cliff from time to time were rolled into balls, sometimes including a flint pebble, just as we see clay-galls now formed on a beach with a cliff of clay.

These were deposited in the accumulating sands, which have a greater development on the northern side of the hill than on the south. A remarkable confirmation of this view of the case was obtained before leaving the pit. In the south-western corner a series of pale grey sands, containing a band of pale blue clay with lignite in small fragments, seemed to be faulted against a pale bluish clay. On cleaning out the apparent fault this was observed not to extend into the upper beds, showing that it was not due to vertical displacements, but was in fact the side of a channel subsequently filled up with another material. Such appearances are termed "horse faults" in the coal-mining districts.

The examination of the Reading Beds being thus concluded, the party inspected a number of bones of Mammalia recently dug out of the Plummery Ditch, which, at the instance of Mr. Harrison Jones, had been kindly exhibited by the Messrs. Palmer. Some of these occurred in a peaty deposit, along with fresh-water shells, below the river sands, and above a bed of gravel. Some came from the lowest gravel. Among the specimens were a portion of a human skull, one half of a horse's jaw, very perfect, with all the teeth; antlers of red deer, very fine; the skull and horn-cores of *Bos longifrons* and the thigh bones of *Bos primigenius?* besides the remains of smaller animals.

The party in the afternoon adjourned to Caversham Chalk Pit. Here, after speculating upon the origin of certain masses of rotten and re-arranged chalk, which occur on the surface towards the lower side of the pit, a search was made for fossils in the flints. Although no *Ventriculites* were found, some very pretty sponges were obtained, besides numbers which were reduced to a pulverulent condition, either by the tap of the hammer, or from previous decay on incomplete silicification. Professor Rupert Jones urged the members to secure and examine some of the white siliceous dust from the round flints, as it consists of beautiful minute organisms.

A walk up Caversham Hill, whence the contour of the country can be well studied, completed the day's work.

[Another excursion to *Reading* took place on June 6th, 1885, J. H. Blake and Dr. Joseph Stevens being Directors. It is reported in the Proc. vol. ix. pp. 209-212. *Reading* was again visited, June 16th, 1888, Mr. Blake again being Director. See Proc. vol. x. p. 493. On July 20th, 1889, *Upton* and *Chilton*, on the Didcot and Newbury Railway, were the scene of an excursion,

W. Whitaker being Director. For report see Proc. vol. xi. p. lxxxiii. Also a paper by A. J. Jukes-Browne (vol. xi. pp. 198-209), written expressly with a view to illustrate this excursion, the illustrations to which are here reproduced.]

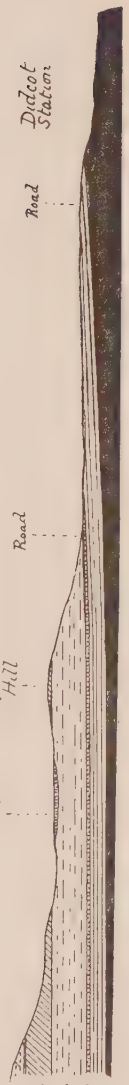

FIG. 93.—SECTION THROUGH CHILTON AND DIDCOT (A. J. JUKES-BROWNE).

Horizontal scale—1 mile to 1 inch; vertical scale—1,200 feet to 1 inch.
N.B.—The patch under "Chilton" is gravel (see map).

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Jones, T. R., and C. C. King, On Some Newly-exposed Sections of the Woolwich and Reading Beds, at Reading. Quart. Journ. Geol. Soc., vol. xxxi., 1875, p. 451.

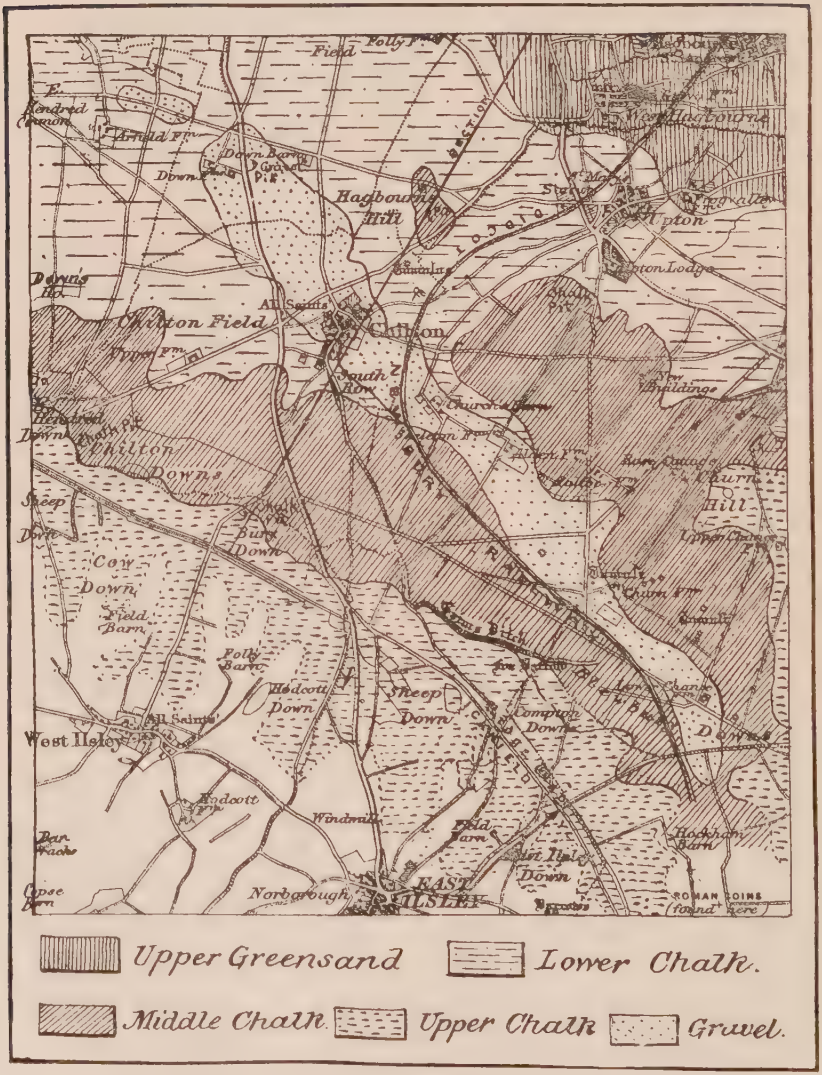


FIG. 94.—NEW (UNPUBLISHED) GEOLOGICAL SURVEY MAP OF THE DISTRICT ROUND CHILTON, BY A. J. JUKES-BROWNE.

Contributed by the kind permission of the Director-General.

(Scale—1 mile to 1 inch.)

EXCURSION TO NEWBURY.—Monday, May 5th, 1879.

Directors—Prof. T. Rupert Jones, F.R.S., and Walter Money.

(*Report by* Prof. Rupert Jones and B. B. Woodward.)

(*Proc. Vol.* vi. *p.* 185.)

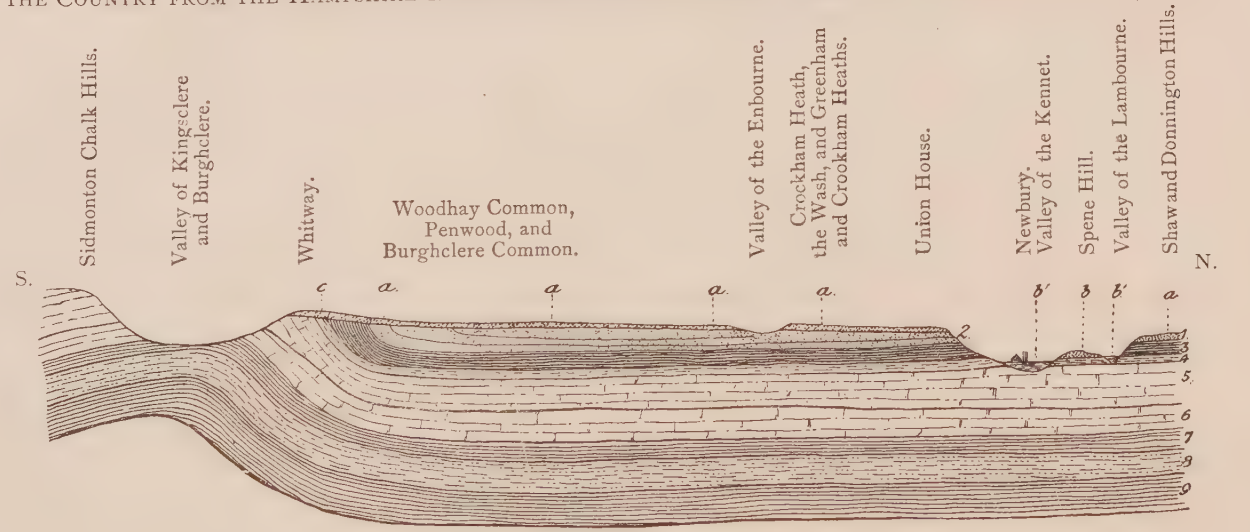
The members, in the first place, went to the Parish Church (St. Nicholas), to see the monumental slab of the celebrated John Winchcombe, or Jack of Newbury. This tablet, built into the wall under the tower, appears to have been cut from a kind of Purbeck Marble, now seldom used, and contains many Unios (?) and other bivalves, with comparatively few Paludinas.

Passing thence to the Museum, the visitors examined the Mammalian remains and shells from the Peaty deposits of the Kennet Valley, and some Roman antiquities from the neighbourhood.

After a short walk the Clay Hill pits were reached. The section here exposed showed all the beds from the Chalk up to the London Clay. Professor Jones pointed out that the surface of the Chalk is here quite level, having formed the floor of the sea-bed on which the subsequent deposits were laid down. The perforations that riddled the upper foot or so of the Chalk had, he said, been attributed by Hudleston to the hollows left by the roots of seaweeds flourishing on the old sea-bottom. Resting on the Chalk were the green coated flints which here form the base of the Reading Beds. These last consist of sandy clays full of green glauconitic grains, succeeded by the Oyster-bed, the blue shales with lignite and plant remains, a bed of fine white sand, and (in the upper pit) the mottled clays of the Reading series, and the lower beds of the London Clay, with its basement-bed here represented by a band of pebbles.

Ascending to the top of the hill a magnficent view of Newbury and the country around was obtained, and an account of the second battle of Newbury was given by Mr. Money. Another short walk and Shaw House was reached, where the party were received by the Hon. and Rev. J. H. Nelson, and, by permission of Mrs. Eyre, the present occupier of this handsome Elizabethan mansion, were enabled to see the relics of the second battle and of the siege of Shaw House, preserved in the Hall. Passing round the grounds of Shaw House, and through Shaw Church, an

FIG. 95.—DIAGRAM SHOWING THE GEOLOGICAL STRUCTURE OF THE NEIGHBOURHOOD OF NEWBURY, BY A SECTION OF THE COUNTRY FROM THE HAMPSHIRE HILLS TO THE HILLS NORTH OF NEWBURY. LENGTH 8 MILES. (JONES.)



a. High-level Gravels.
b. Low-level Gravels.
b'. Peat-beds and low-level Gravels.
c. Outcrop of the Lower Clays and Sands (covered by superficial Gravel).

1. Gravel of the Heaths.—Post Tertiary.
2. Bagshot Series.
3. London Clay.
4. Woolwich and Reading Series. } Tertiary.

5. Upper Chalk.
6. Lower Chalk.
7. Upper Greensand.
8. Gault.
9. Lower Greensand. } Cretaceous.

advance was made on Donington Castle. The castle stands on a spur of the Chalk capped by Lower Tertiaries. Some interesting examples of swallow-holes were pointed out by Professor Jones.

The party mounted the winding stairs of the castle and studied the physical features of the landscape, with the Chalk Hills of Hampshire bounding the wide heaths of Bagshot Sands on the south.

Traversing, by permission of Mr. Best, the grounds belonging to Donington Grove, through which the Lamborne flows, and passing through the village of Spene, the next halt was made at "Our Lady's Well." This ancient and once holy well is fed by springs from the gravel on which the village stands. To the presence of these springs the coombe-like valley below is to be traced. After tasting the water and testing the echo between the well and the neighbouring church the march was resumed towards Spene Moors. Spene Church, with its very old dedication stone of cross and circle, was passed in the opening of the coombe.

A few yards lower down Professor Jones pointed out a section showing the subsoil of chalk on which reposed the old gravels of the river. Still lower down in the broad, level valley of the Kennet some very interesting sections in the peaty deposits were visited. Some spots were pointed out where the peat had, comparatively a few years back, been excavated, and the hollow entirely filled up with fresh accumulations of vegetable growth. In one notable instance the peat had only twenty years ago been dug out to a depth of ten feet, but the pit is now filled in to within three feet from the top, *Equisetum* being an active agent among the infilling plants.

Resting on the top of the peat was a calcareous, loamy bed, full of shells of land and fresh-water Mollusca, and locally called "Malm." This "Malm," or Marl, like the brick-earths of the lower Thames Valley, is a flood-water deposit, the shells having been left behind when the swollen stream returned again to its usual channel. Layers of dead *Limnæa*, coating the bottom of nearly dry ditches in the water-meadows close to the Kennet, served as existing samples of such an accumulation of shells.

The best example, however, of this "Malm" was seen in a shaft in the West Fields, close to the town, sunk for the occasion by the borough surveyor, Mr. Sargent. Many of the shells found in this section were coated with concretionary carbonate of lime. A like incrustation coats the Caddis-worm cases, so that they resemble those of the Indusial Limestone of Southern France.

Mr. B. B. Woodward remarked that, with regard to the

incrusted cylinders and Caddis-cases, the first that was opened was probably the mould of a twig. In the next example were a number of smaller incrusted twigs, which had, from their size, been apparently used in the construction of a case of basket-like interlacement, in true Caddis fashion. Another seemed to have been built of the thin leaves of water-plants, and may have belonged to the swimming Caddis; whilst a fourth exhibited in its wall a small shell *(Planorbis)*, evidently from its position once part of a Caddis-case.

Returning to the Town Hall the party were received at dinner by the Mayor, the Rector, some members of the Corporation, and of the Field Club.

[*Newbury* was visited by about twenty members of the Geologists' Association on March 29th (1888), under the leadership of Messrs. W. Whitaker and F. J. Bennett, of the Geological Survey. On the morning of Saturday, the 31st, the party left *Newbury* for *Highclere*, on the Newbury and Winchester Railway, and after inspecting the sections on the railway between *Highclere* and *Litchfield* and the camp on *Beacon Hill*, took train for *Winchester*. On the following Monday (Easter), they left *Winchester* or *Southampton* for *Christchurch Bay*. (See Proc., vol. xi. p. xiii.).]

References.

Maps.—(The same as for Reading, see p. 273.)

Books.—(The same as for Reading, see p. 273.)

Jones, T. R., A Lecture on the Geological History of Newbury, 8vo, London. 1854.

Jones, T. R., The Geology of the Kennet Valley. Trans. Newbury District Field Club. 1872.

Jones, T. R., On the Geology of the Kingsclere Valley. Geol. Mag., 1872, p. 511.

[*Faringdon* appears to have been first visited in 1865. No account of this excursion exists, but a "Sketch of the Geology of Faringdon," by C. Evans, may be seen in "The Geological and Natural History Repertory" No. 15, pp. 33-40 (July, 1866). This sketch appears to have been read to the Geologists' Association previous to the excursion. *Faringdon* and *Swindon* were visited at Whitsuntide, 1876; *Swindon* on Monday, June 5th, and *Faringdon* on Tuesday, June 6th. As *Swindon* is about eleven miles from *Faringdon*, and in the adjoining county of *Wiltshire*, the report below is confined to the *Faringdon* part of the excursion.]

EXCURSION TO FARINGDON—June 6th, 1876.

Directors—Prof. John Morris, F.G.S., E. C. Davey, and C. J. A. Meÿer, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 548.)

The party assembled at Faringdon about 10 a.m. Mr. Davey assumed the lead and was assisted by Prof. Morris and Mr. Meÿer. The great features of interest in this district are the Sponge Gravels of Lower Greensand age, but there are also some instructive sections of Corallian beds. The party drove to Badbury Hill, a commanding point, situated on the escarpment which overlooks the valley of the Upper Thames, about two and a half miles to the west of Faringdon. The subjoined extract from Mr. Meÿer's paper* will serve to show the nature of the equivalents of the Red and Sponge Gravels of the pits subsequently visited.

"Our next excursion was to Badbury Hill. In a small pit near the roadside, on the west slope of the hill, and at about fifty feet from the top, we found a section exposed, which was to me by far the most interesting one I had yet seen. The section was as follows :—

†	Light-coloured and ferruginous sand, with slabs and fragments of chert, apparently the debris of higher beds	14 feet.
a	Fine ash-coloured sand, *regularly stratified*, very like the sands with clay beneath the ironstone of Furze Hill	4 feet.
b	Dark brown and ferruginous sand, with a mixture of small pebbles, Bryozoa, Terebratulæ, &c., regularly stratified	4 feet.
c	Ditto, ditto, with two or more bands of hard calcareous concretions, each about eight inches in thickness	5 feet.

This last was the lowest stratum exposed, but from the appearance of the soil the pebbly sands extended somewhat lower.

* Geologist, vol. vii. p. 5, *et seq.*

"In the looser materials composing the strata *b*, *c*, we immediately recognised the upper portion of the Red Gravel of East Pit, containing here, as there, *Rhynchonella nuciformis* in abundance, *R. latissima*, *R. depressa*, *Terebratella Menardi*,* *Terebratula tornacensis*, *T. depressa*, more rarely; and, in addition, a few specimens of *Terebratella oblonga*, Sow.

"In the intermediate stone beds, *c*, *T. oblonga* was not uncommon, associated more rarely with *R. depressa*, *T. Menardi*, *T. depressa*, *T. Robertoni*, D'Arch. The stone also contained *Avicula Rauliniana*, D'Orb., *Pecten Raulinianus*. D'Orb., *P. orbicularis*, *Exogyra conica*, var., and *E. haliotoidea*—shells which occur in the 'Bargate stone' and 'Pebble beds' of Godalming. In fact, except from the greater abundance of organic remains, this section agrees precisely with a section exposed in a quarry of the Lower Greensand near St. Katherine's Chapel, Guildford, where 'pebble beds' alternate, for a thickness of twenty feet or more, with layers of the 'Bargate stone.'

"I was greatly pleased at finding *Terebratella oblonga* here in such comparative abundance, associated with *T. Menardi*, &c., as I had only met with a single specimen in the Sponge Gravels. Yet what seemed to me of greater interest in this Badbury Hill section was the upward passage of the dark-coloured pebbly gravel *b* (red gravel) into *a*, thus, as it were, limiting the position of the Sponge Gravels with a definite vertical range; the fine sandy strata, *a*, underlying the ferruginous sands with chert and ironstone as well here as at Furze Hill and Faringdon Clump.

"From what I have now seen of the several sections in the neighbourhood I can form but one opinion of the Sponge Gravels with relation to the surrounding deposits, viz., that the true 'Sponge Gravel' of the Windmill Pit is unquestionably *the oldest of the Crétaceous deposits near Faringdon*, the strata exposed in the sections of East Pit and Badbury Hill forming as nearly as possible a continuous series; while at the same time there is no reason to doubt that the fossiliferous concretions capping Furze Hill are identical with the ironstone concretions which occur near the top of Badbury Hill, intermingled here and there with the cherty fragments."

In the above paper the author gives comparative sections at 1, Furze Hill, 2, Badbury Hill, 3, East Pit, Little Coxwell, 4, Windmill Pit, Little Coxwell—the two last were visited later in the day.

* Now recognised as the *T. truncata* of Sowerby.

From the summit of Badbury Hill, said Prof. Morris, the view toward the north-west was bounded by the south-easterly slope of the Cotswolds, the surface inclination being rather less than the angle of the dip. In the immediate foreground towards the north was the vale of the Upper Thames, which lay in the plain of Oxford Clay, between the Lower Oolites of the Cotswolds and the Corallian escarpment, of which Highworth might be deemed the culmination, but which, at Badbury, was heightened by the superposition of the Neocomian beds they had seen. Neglecting the small Portlandian escarpment, almost unnoticeable from this point, they saw on the south the Vale of White Horse, excavated out of the Kimeridge and Gault Clays, and extending along the foot of the third (at Swindon enumerated as the fourth) great escarpment, formed by the Chalk hills above Wantage. Thus three clay vales, viz., that of the Lias, the Oxford Clay, and the Kimeridge-Gault were subtended by three limestone escarpments.

But the masses of siliceous grit or Grey Wethers, remnants of strata of Tertiary age, found in the low grounds beyond the Chalk escarpment near Swindon, attest the waste to which the whole district has been subjected, and clearly show, as explained by Professor Ramsay, how the Chalk and overlying Eocene beds once spread far across the plains which the Chalk escarpments overlook, and which latter have thus gradually receded eastward.

Mr, Davey then read out to the party some notes on the subject of Badbury Hill, of which the following is an extract:—

"The camp is 200 yards in diameter, with a ditch twenty feet wide. Some nine years ago (written about 1800), in levelling the north rampart, human bones and coals were found and human bones are found every year in digging for peat in the swampy ground about one mile south of the hill."

"Mr. Austen found fossil wood and the leaflet of a fern on the tabular summit (Quart. Journ. Geol. Soc., vol. x. p. 457); Mr. Cunnington, *Terebratella oblonga* (Quart. Journ. Geol. Soc., vol. x. p. 177); myself, *Domopora*, *Emarginula neocomiensis*, *Turbo*, *Rhynchonella Gibbsiana*," &c.—

The party then descended by a pleasant route across the fields to Great Coxwell Barn, which is favourably situated on Corallian limestone by the side of a spring, thrown out at the base of the Neocomian sands, which are an extension of those on Badbury Hill. This is effected by a narrow belt of Kimeridge Clay

interposed between the sands and the limestones. The contrast between the vegetation of the poor, hungry sands, covered with short grass and daisies, and the golden meadow formed by the mixture of the sands and clay below, could not have been more sharply indicated by colour on a map. The old monastic barn, built in the year 1204, is still made use of by the tenant of this portion of Lord Radnor's estate.

The next move was to the celebrated Sponge Gravel pit, the "Windmill Pit" of Meÿer's Section, previously quoted, but usually known as Ballard's Pit, situated near the village of Little Coxwell. This place has long been celebrated for the crowds of fossils which it contains, and it has in consequence attracted the attention of geologists. D. Sharpe has given a description of the Sponges, and other remains (Quart. Journ. Geol. Soc., vol. x. p. 176), which he was induced to refer to the period of the Chloritic Marl, an opinion we have seen combated by Mr. Meÿer, whose views are generally acknowledged to be correct. Further details, with admirable photographs of some of the sponges, are to be found in an article in the "Proceedings of the Newbury Field Club," written by Mr. Davey, who, in a subsequent memoir on the Faringdon Sponges, has, with the approbation of M. E. de Fromentel, materially altered the names given by Sharpe. Besides the sponges there is an abundance of Polyzoa, Echinodermata, and Brachiopoda. *Peltastes Wrighti* (tests), and the spines of *Cidaris faringdonensis*, are specially numerous. Fragments of the spines of *Cidaris florigemma*, derived from the Coral Rag, also occur.

Despite its gravelly appearance, the calcareous nature of the general mass is evident, most of the sponge fragments themselves being calcareous. The formation generally is loose and porous, with deep potholes towards the top filled in with an admixture of the Red Gravel, so well exhibited in the next pit (Boutcher's). There are a few bands of hard stone of a greenish or pinkish tinge, due probably to the suffusion and partial decomposition of glauconitic matter.

Mr. Meÿer considered that the Sponge Gravel here reposed partly on Kimeridge Clay and partly on Coralline Oolite. The gravel of Boutcher's Pit underlies the iron-sand of Furze Hill, but it seems probable that the Sponge Gravel of Ballard's Pit does not pass *continuously* under any of these other beds. It was true that there was a certain resemblance between the Brachiopoda of the Tourtia beds of Belgium (representing our Chloritic Marl) and

these, but the resemblance was one of representation rather than of identity. Thus we had here *Rhynchonella latissima*, in the Tourtia *R. compressa;* here *Terebratella truncata*, in the Tourtia *T. Menardi*, and so on. As regards the mode of occurrence of this great sponge bed, in the Neocomian sea the Coral Rag would here rise in ridges on which the sponges grew in suitable localities. Towards the south, in the direction of deeper water, the Sponge Gravel loses its character. The sponges probably grew in a strong current, which caused them to require powerful attachments in order to maintain their position. When overthrown they would be swept into heaps like this, along with an occasional ammonite, and with multitudes of attached shells, chiefly Brachiopoda, such as *Terebratula sella*, *Waldheimia tamarindus*, *Thecidium faringdonense*, and others already named.

Professor Morris could endorse much of what Mr. Meÿer had advanced, especially as regards the Tourtia beds of Belgium, their fossils being representative of, rather than identical with, those of the Faringdon Lower Greensand. There could no longer be any doubt as to the true position of the Faringdon Beds. Towards the south-east of England the trifold series of the Lower Greensand was complete, but in a north-westerly direction the beds were thinning out, the upper series alone being continued in this direction, and thus transgressive, as is usual in an area undergoing continuous depression. He concluded by noticing the great resemblance of this peculiar rock to the Coralline, or, more properly, Bryozoan Crag of Suffolk, pointing out also the number of derivative shells, and suggesting that during its deposition portions of the Wealden area might have been still unsubmerged.

The last place visited was Boutcher's, or the East Pit: noteworthy fossils *Rhynchonella nuciformis*, *Trematopygus*, *Nautilus lævigatus* (?). The beds are composed chiefly of small pebbles in ferruginous sand; the pebbles are mostly quartz, with some lydites and green rock. There is less calcareous matter than in the other pit, and the upper part is less perforated by potholes, rounded masses of buff clayey-calcareous stone bored by a richly sculptured *Modiola* (?) are not unfrequent. The Sponge Gravel of the other pit may be seen in one corner, at the base of this series.

The day's proceedings were brought to a close by a dinner at the Crown Hotel, Faringdon.

References.

Maps.—(Same as Reading, see p. 273)

Books.—(See references in text of the excursion.)

EXCURSION TO WANTAGE.—Monday, May 7th, 1877.

Directors—Prof. John Morris, F.G.S., and E. C. Davey.

(*Report by* E. C. Davey and W. H. Hudleston, F.R.S.)

(*Proc. Vol.* v. *p.* 137.)

This was an excursion to a certain extent supplementary to the Faringdon Excursion of the previous year (Proc. Geol. Assoc., vol. iv. p. 543). Mr. Davey, who had on that occasion acted as the chief local Director, was desirous to complete the history of the "Sponge Gravel" district, by exhibiting to the members the unrivalled collection from those beds which is stored in his private museum at Wantage.

After delivering a short address explanatory of the Cretaceous geology of the neighbourhood Mr. Davey conducted the visitors to his museum, in which were displayed a fine series of the fossils of the district, together with collections of coins, pottery, celts, and the spolia of a Roman villa recently discovered near Wantage, an account of which was read before the Archæological Institute in 1877. The fossils are all catalogued in a pamphlet printed expressly for the members of the Association, copies of which are to be seen in the Library.

After partaking of the hospitality of Mr. Davey the party proceeded in conveyances to Lockinge Clump, East Hendred, and Cuckhamsley Hill. The lowest Cretaceous beds seen on the route are known as Firestone, resting on the Gault and forming a prominent narrow ridge, which overlooks and bounds the Vale of White Horse for many miles in succession. No fossils had hitherto been reported from this zone in Berks, but Mr. Davey has obtained more than a dozen species, the most remarkable being some Echinoderms of the genus *Cardiaster*. The most abundant species is flat, with five ambulacra—a specimen of which may be seen in York Museum labelled *Micraster Murchisoniæ*. Besides these urchins the Firestone contains *Pecten orbicularis*, *Pholadomya decussata*, *Plicatula inflata*, and three species of *Nautilus*.

Resting on this Firestone are beds, thirty feet in thickness, of soft glauconitic sands well exhibited in various sections round Wantage, and seen on Lockinge Clump. These sands are

decidedly fossiliferous, especially in their higher portion, and yield *Pecten asper*, *Discoidea subuculus*, *Pleurotomaria Rhodani*, *Terebratula biplicata*, and other species characteristic of the Warminster beds with which the Wantage sands seem identical (see Quart. Journ. Geol. Soc. for 1875, p. 272, and Barrois, "Récherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," pp. 36, 62, 70).

After passing through East Hendred the members visited a quarry of Lower Chalk (zone of *Holaster subglobosus*) half way up Cuckhamsley Hill. This hill has other attractions besides fossils, for on its summit is a large mound, which Kemble supposed to be the most commanding barrow in England, and the resting-place of Cwichelm, the first Christian king of Wessex ("Archæological Journal" for 1857, p. 131). Arrived on the summit of the downs the party was addressed by Professor Morris on the physiography of the immense district which is commanded by this elevated ridge.

After exhausting the geological side of the subject the history of the district came in for its share of attention, and a discussion ensued between Mr. Davey and Mr. James Parker as to the origin of the name of the mound which is on the summit of this part of the Wantage Downs. It might be gathered from what was said that the boundary between Wessex and Mercia in these parts seems to have run along the line of the Chalk escarpment.

A general move was now made to a fine section in the nodular Chalk Rock, 500 yards west of Cuckhamsley Barrow. The more this bed is studied, the more striking seem its peculiarities. The Chalk Rock may be seven and possibly ten to twelve feet in thickness, but nine-tenths of the fossils are found in a seam that rarely exceeds three or four inches in depth. Above this thin layer fossils are scarce and restricted to half-a-dozen kinds; below, the rocks are devoid of any but minute organisms. Above, the Chalk is milk-white, soft, and interspersed with flints; but the Chalk Rock is hard, cream-coloured, filled with dark phosphatic nodules, and contains no flints. Above, not a single gasteropod has yet been discovered;* but the moment the Chalk Rock is reached an extraordinary assemblage of univalves is disclosed. Deep-sea bivalves are present, but the majority of the fossils belong to the genera *Trochus*, *Cinulia*, *Pleurotomaria*,

* According to Professor Phillips Gasteropods are unknown in any part of the Yorkshire Chalk, "Rivers, Mountains," &c., chap. vii. p. 182.

&c., and these are all inhabitants of shallow waters. Nevertheless, the Chalk Rock contains no trace of sand or pebbles or wood, to denote the vicinity of land. The conditions under which the Chalk Marl was deposited seem to have been repeated in the Chalk Rock—both being "littoral" and not "abysmal" deposits —for we find *Hamites*, *Scaphites*, and gasteropods in both. Of the Echinoderms the most abundant and characteristic is a dwarf species, which is probably that distinguished as *Cardiaster pygmæus* of Forbes, by Price (On the Beds between the Gault and Upper Chalk near Folkestone, Quart. Journ. Geol. Soc., vol. xxxiii. p. 431.) From these remarks it will be gathered that the Chalk Rock is a stratum of peculiar interest and, worth the attention of palæontologists. Numerous quarries are worked in this rock near the summit of the Berkshire Downs, from Ilsley to Uffington, and afford excellent opportunities for further investigations and discoveries.

The journey homewards was accomplished by a pleasant drive along the ancient grassy road known as the Ridgeway and downward through the grounds of Betterton House and Lockinge Park. Wantage was reached at half-past five.

[The next excursion, that to *Camberley*, is grouped with *Berkshire* rather than with *Surrey* excursions, chiefly because it is one of a series of three to the Bagshot district, on the borders of the counties of *Surrey*, *Berkshire*, and *Hampshire*. The second of these, to *Wokingham*, *Easthampstead* and *Ascot*, was wholly within the frontiers of *Berks;* while the third, to *Aldershot* and *Wellington College*, was within the confines of *Berkshire* and *Hampshire*.]

EXCURSION TO CAMBERLEY.—April 24th, 1880.

Directors—Prof. T. R. Jones, F.G.S., The Rev. Dr. A. Irving, F.G.S., and Capt. C. Cooper King.

(*Report by* The Directors.)

(*Proc. Vol.* vi. *p.* 329.)

The members were met at the Camberley Station.

A start was made for the Flint-implement Station, near the Staff College, on the confines of Surrey and Berks. On arriving at the lateral *cul-de-sac* of the Wishmoor Valley, in which the flint

station is situated, Capt. King pointed out that, from its shape, and from the line of gravel which lies at an almost regular level along the sides of the existing hills, the area seems to have been at one time a lake, the western barrier of which is now represented by a small hog-backed hill. This has evidently been gradually worn away by the two brooks which still exist, allowing the lacustrine waters to escape. The floor of the valley contains much silty matter, with stems of wood, resting on a thin clay, and it was in this silty sand that the flint flakes and some flint implements were found. They are not distributed equally over the valley bottom, but lie in definite patches. It was therefore probable that the ancient folk occupied either natural or artificial elevations in the marsh or lake. Some sections of the special spots, exposed for the purpose, displayed the sandy and silty nature of the soil with its numerous fragments of decayed woody matter and a few flakes.

Leaving this interesting lacustrine valley, the high road from London to Salisbury was crossed and Obelisk Hill ascended. It was pointed out that the glen at its foot is continuous with some of the ancient hollow road-tracks, whilst others pass the southern foot of this small, well-marked, conical hill. The gravel capping the summit is highly ferruginous, forming "pan," and has resisted the eroding agents which carved the numerous valleys all round out of the Post-Tertiary gravel plateau. The general structure of the country was described by the President, who briefly alluded to the Lower Tertiaries let down in the shallow syncline between the Chalk hills of Surrey and of Bucks, to their having been planed down by marine denudation, and to their coating of gravel, consisting of (1) subangular flint from the Chalk, (2) pebbles from the lowest Tertiary beds, (3) water-worn fragments of Neocomian chert from beyond the Guildford gap, (4) more or less worn "Sarsdens," or consolidated blocks of the Upper Bagshot Sands, (5) small pebbles of quartz, and (6) occasional masses of sand, frozen when originally embedded. The subsequent erosion of this Post-Tertiary plateau was referred to the action of sea-creeks and streams.

A descent into the valley on the southern foot of the hill led across some of the ancient road-tracks, now much obliterated by cultivation, and to openings in the low-level gravel, here thicker than usual. Sarsdens are frequent here, mostly much water-worn.

On the top of Crawley (Portesbury) Hill, forming the southern

side of this Camberley Valley, the plateau-gravel, with its overlying loam and its ferruginous layers, is well seen in the railway cutting. Here the gravel and loam die out in thin beds on a sloping and eroded floor of Bagshot Sand, at the former head of one of the old sea-creeks.

Regaining the high road, near Hangman's Lane, the party soon reached the "Jolly Farmer," an inn situated in the angle at the junction of the Portsmouth and Southampton roads. The "Golden Farmer," which was on the northern side of the road, was formerly associated with the nefarious doings of Dick Turpin, before the present road superseded the many old trackways on the heath. Going northwards the excursionists, on Penny Hill, had a beautiful view over the Bagshot Valley, with the Windsor crest-line in the distance.

A walk through the heather and pine-woods of Easthampstead Plain, and across the Wishmoor Valley, brought the party, by Hermitage Hill, to the intersection of five forest-rides, known as Wishmoor Cross, a name transferred from the old Hermitage *Cross*. Their further progress soon led them across the old Roman Road, from ad-Pontes (Staines) to Calleva (Silchester), known as the Devil's Highway, and the Nine Miles Ride. Where this ancient highway is crossed by a set of forest-rides is a small grassy mound marking the place of a former gallows-stem, on which some highwaymen suffered death.

One of these forest-rides led direct to the southern entrance of the old British Camp, known (like others about the country) as "Cæsar's Camp." Dr. Irving here gave an account of what was known of the camp. Its name is a misnomer, though the spot may have been occupied temporarily by a Roman legion. It occupies the northernmost spur of the Easthampstead Plain, near Bracknell, and, as a military position, would enable an army holding it to command a considerable portion of the valley of the Thames. The northern end of the spur is capped with the usual gravels of the country. These gravels have become in many instances so closely bound together by oxide of iron as to form the most effective protection to the soft and incoherent strata of the Bagshot country; and it is to these that the peculiar contour of the country about Wellington College is due. The conical hills of Edgbarrow and Ambarrow, and the various long lines of hills, known locally as ridges, owe their preservation against erosive agencies to the presence of such gravels and conglomerates.

Crossing over to the western side of the camp, where, on the steep slope of the hill, the so-called double ditches and valla were well defined, Captain King remarked that it seemed doubtful whether these earth-walls or valla could be looked on as successive lines of defence. Owing to the short range of early missiles, it would be almost impossible to hold both ridges at the same time, the command of one over the other being so slight; and, further, the retreat from the outer banks into the body of the fortress would scarcely be effected by a direct run from one to the other, as such retreat might be accompanied by a rush of the enemy, entering the camp perhaps with the defenders. As probably, also, the inner vallum was crowned by a wicker breast-work (which would be impervious to most of the missiles), the retreat would naturally be made by the gates, and to do this the defenders of the outer vallum would have to find their way round to these entrances, exposed to the enemy's attacks during the movement. It therefore seemed more likely that the object of the outer vallum was only to provide sufficient earth to make the inner ditch a more formidable obstacle to an assault. The camp, from its "trace" and simplicity, was evidently British. Some fragments of Romano-British pottery were afterwards found in the black soil of one portion of the interior.

The association of the camp with the name of Cæsar is no doubt due to the presumed Roman settlement or town, of which numerous traces have been found, about half-a-mile to the south of the camp. The site of this, long known as "Wickham Bushes," has been lately re-explored by Mr. W. Goodchild. Many fragments of pottery and specimens of roofing-tiles, both of undoubted Roman origin, have been exhumed, and a coin of the reign of Probus has been discovered.

Capt. King remarked of Wickham Bushes that, although the grassy area, dotted with ancient thorn-trees and oaks, contained much Romano-British pottery, it does not therefore follow in the least that the settlement was formed, or even occupied by Romans. The circular hollows which dot the ground at varying intervals would seem to indicate the sites of pre-Roman pit-dwellings; and the presence of Roman remains may only indicate that the village existed up to Roman times, and that Roman loot was brought thither from other places.

The excursionists had then to leave the plateau and the beautiful view, and, crossing the Roman road at a point eastward of the former transit, they dipped into a narrow wooded valley

and then descended Lodge Hill. Here they saw a pit in the high-level gravel, with striking evidences of the intervention of floating ice in modifying the constituent layers of gravel, sand, and loam, during and after their deposition. Want of time prevented the ascent of Edgbarrow Hill, the summit of which is fortified by ferruginous "pan."

Time did not admit of an inspection of the sections exposed in the brickfields of Wellington College and in the adjoining railway cutting. The Bagshot strata are characterised here, as elsewhere on the same horizon, by the great abundance of well-rolled pebbles of black flint, which are scattered through the sand, with the rarest possible occurrence of any material from a more distant source than the Cretaceous formations.

FIG. 96.—SECTION FROM FRIMLEY RIDGES TO WOKING STATION. (PRESTWICH.)

	Feet.
a. Upper Bagshot Sands, few casts	150
b. Middle Bagshot Sands	—
1. Greenish Sand, with a few Pebbles	2
2. Foliated Sandy Clays (brown)	11
3. Grey Clay, with traces of lignite	1
4. Green Sand, with teeth, bones, and casts	16
5. Compact Lignite	1
6. Sandy Clay, the upper part with green sand tubes	6
7. Brown compact Clay, with sand and traces of vegetable remains	8
c. Lower Bagshot Sands	130
d. London Clay	—

x. Interval of 3 miles. † Interval of ¼ mile. In both these spaces the strata are continuous. --------- Strata proved.

FIG. 97.—SECTION OF BAGSHOT SANDS EXPOSED IN THE RAILWAY CUTTING AT WELLINGTON COLLEGE.

(Length of section three-fourths of a mile.)

3. Pebble-bed, well-rolled Pebbles of black flint in a matrix of sand (often greenish).

4. Yellow and buff-coloured Sands and Loam (occasionally brick-red), much eroded on the upper surface. Thin layers of pipe-clay, irony concretions, and black and green-coated flints.

5. Clay; the lower part more compact and tenacious, the upper somewhat laminated, with frequent small inter-bedded layers of green sand, and occasionally a few Pebbles. At * the Clays are slightly contorted.

[Reports of the excursions to *Wokingham*, *Easthampstead* and *Ascot*, July 18th, 1885, and to *Aldershot* and *Wellington College*, July 11th, 1885, may be seen in Proc. vol. ix. pp. 219-224. The Rev. Dr. Irving was Director on both occasions. Other excursions to the Bagshot district took place in 1890—one to *Aldershot* and *Brookwood* on June 14th, 1890, the Directors being Messrs. H. W. Monckton and R. S. Herries; the other on June 21st to *Wokingham* and *Wellington College*, directed by Dr. Irving.]

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New Ordnance Survey. Sheets 269, 285. 1*s*. each.

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[The Bagshot District has formed the subject of numerous Papers in the last ten years of the Quart. Journ. Geol. Soc., the Geol. Mag., and the Proc. Geol. Assoc., the authors being Dr. A. Irving, H. W. Monckton, and R. S. Herries.]

SOUTHERN COUNTIES.

HAMPSHIRE AND THE ISLE OF WIGHT.

EXCURSION TO THE HAMPSHIRE COAST.—Easter Monday, March 29th, and Following Day, 1880.

Director—J. Starkie Gardner, F.G.S.

(*Report by* J. S. Gardner.)

(*Proc. Vol.* vi. *p.* 316.)

The headquarters of the Association were fixed at Bournemouth.

First Day.—The members met together at Bournemouth Pier and proceeded along the shore towards Boscombe. On the way the Director pointed out the position of the Bournemouth series in the Eocene formation, and the chief geological features of the coast. Far to the west, and close to Poole Harbour, could be seen the cliffs, which contain a rich dicotyledonous flora, the leaves from forest trees which clothed the hilly slopes of the right bank of the Eocene river. This flora, or rather series of floras, differs remarkably from those found nearer towards Bournemouth, especially in the hitherto absence of remains of palm. The central ranges of cliffs are almost unfossiliferous, and from their confused bedding are conjectured to present a transverse section of the silting up of the old river channel. From the pier the eastern series of leaf beds extends for nearly a mile, containing the remains of a very much more tropical-looking flora, probably derived from the low-lying shores of the left bank of the river. Among the palms, which are very abundant, such genera as *Phœnix*, *Calamus*, *Iriartea*, *Sabal*, &c., are conspicuous, and among the ferns, some scarcely differing from such magnificently tropical forms as *Osmunda javanica* and *Chrysodium aureum*, *Gleichenia dichotoma*, *Lygodium dichotomum*, &c. Beyond these cliffs, skirting the nearly vertical Chalk downs, are the Lower Bagshot beds, in which the well-known leaf beds of Alum and Studland Bays are found, and beneath these the Lower Tertiaries. Only the upper part of the Bournemouth fresh-

water series, which is estimated to be 400 feet thick, was actually passed on Monday. The broken angular blocks, embedded in sand, whence come *Aroides* and a representative of *Araucaria Cunninghami*, not met with higher in the series, were pointed out. Within a few hundred yards the fresh-water series, with its white clays, sharp quartzose sands, and absence of flint, became replaced by the marine series. Owing to the absence of any slips, and the consequent inaccessibility of most of the beds, few fossils could be obtained, although indistinct impressions of the reticulated fern-fronds, from strata which immediately underlie the marine beds, were seen.

The passage of marine to fresh-water beds at this point was seen. The marine beds are stiff liver-coloured clays, becoming black on exposure, containing casts of several genera of Bryozoa and of Crustacea, and greenish sandy clay with casts of Brackleshам molluscs. They are highly charged with lignitic matter, and contain in places very perfect fruits, and much teredo-bored wood. Overlying them are the clean white sands, with flint shingle-beds of the Boscombe series, and above these a thick capping of angular Quaternary gravel. The Eocene shingle-beds consist of perfectly rounded flints, showing the existence, at the time they were deposited, of a heavy surf. In many cases the condition of the silex is changed, and pebbles appear to be soft, chalk-like masses. They are met with in every stage of the change, wholly converted, with black flint nucleus, half converted, or merely with a thickened white coat. Nearing Boscombe the positions of the various fruit-beds were pointed out, and the curious tubular borings of annelids, filled with horizontally-arranged lignitic matter or with fine sand, which in places riddle the dark clays. At the corner of Boscombe Chine instances of the denuding power of wind were seen, and in the extraordinary Honeycombed Chines, the effects of springs in rapidly excavating deep *cirques* in the soft strata. The zone of *Nipadites* was well seen, the empty husks that had floated out to sea, and were now filled with sand, being in places crowded together. At another spot fragments of proteaceous or myricaceous leaves were found.

The party then proceeded to Hengistbury Head, a distance of about four miles. On the way it became apparent that, as the fresh-water beds present a transverse section across a vast river-channel, so the marine beds present a section through a great Eocene beach or sandbank, behind which lay a stagnant lagoon.

The shingle in them became larger and larger towards the east, its well-rolled appearance indicating the distance it had travelled. Attention was called to the resemblance of these beds to the so-called Upper Bagshots of the London Basin.

The principal features of the headland itself were fully described in the Quart. Journ. Geol. Soc., vol. xxxv. p. 213, and the divisions were clearly made out. Having skirted the Head along the shore, the party mounted to the top over the *débris* of the old quarries, and, after enjoying the view, made their way through the heather, past the prehistoric double ramparts and ditch, to the ferry over the Stour and Avon and thence to Christchurch.

Second Day (*Tuesday*).—The party proceeded by rail to Christchurch, when the fine Norman house attracted attention, and the church was again examined while waiting for conveyances. The different building-stones used were pointed out by Mr. Birch. These included Hengistbury ironstone for the foundations, and Bembridge, Binstead, Headon, Portland, Purbeck and Caen limestones for the edifice. The members then drove to Midderford, and thence found their way along the base of the cliffs to Highcliff. The new channel recently created by the Stour and Avon for a mile along the base of these cliffs caused much interest, the outfall of the rivers being just below Highcliff.* The main features of the coast were described, the sequence of the beds from Hengistbury to Highcliff, the Barton Clays and Sands, the Upper Bagshot and Headon Beds of Hordle.

The party dispersed to collect the Barton shells, which usually lie exposed in thousands upon the slopes of the cliffs, and many beautiful specimens of the characteristic shells and teeth were obtained. Beyond Churton Bunny most of the party again came together. Owing, however, to the shingly character of the beach, a large number soon chose the coast path, and viewed the Hordle part of the series from above. During a short halt the magnificent panorama which stretched for fifty miles, embracing the Isle of Wight, the Solent and the whole coast to St. Alban's Head, and the Purbeck Hills, was surveyed. The members soon after entered the conveyances provided for them at Milford, and drove to Lymington.

* At the Easter excursion, 1888, the outfall was seen to be nearly at the spot where it is shown on the old Ordnance map, about 1½ miles west of the mansion called Highcliff.

[*Christchurch Bay* was again visited on Easter Monday and Tuesday, 1888 (April 2nd and 3rd), W. Whitaker and J. Starkie Gardner being Directors. A report of this excursion will be found in Proc. vol. xi. p. 17].

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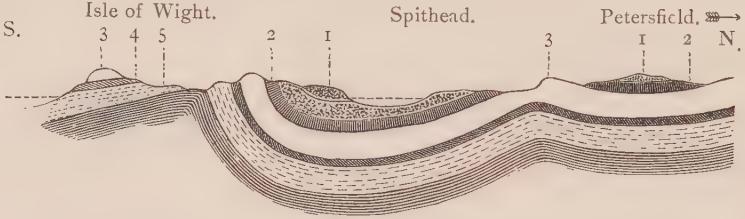
See also Keeping, Elwes and Wood, Geol. Mag., 1883, pp. 428, 493, 527, 573.

FIG. 98.—SECTION FROM SOUTHSEA TO PORTSDOWN.

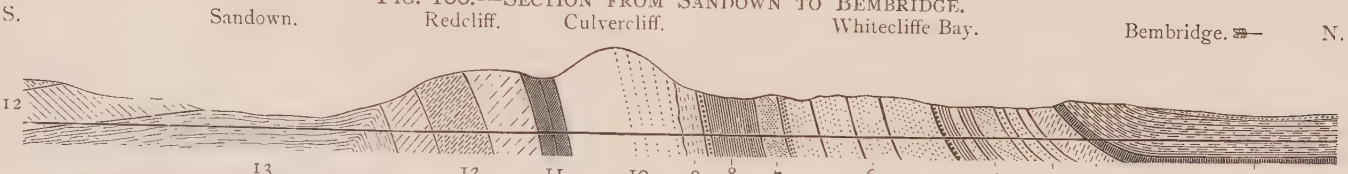
1. Gravel. 2. Bracklesham. 3. Lower Bagshot. 4. London Clay and Bognor Beds. 5. Mottled Clay. 6. Chalk.

FIG. 99.—SECTION FROM VENTNOR TO PETERSFIELD.



1. Upper Middle Eocene. 2. Lower Eocene. 3. Chalk. 4. Middle Cretaceous. 5. Lower Cretaceous.

FIG. 100.—SECTION FROM SANDOWN TO BEMBRIDGE.



2. Bembridge Series (capped with Gravel to N.). 3. Osborne. 4. Headon. 5. Barton. 6. Bracklesham. 7. Lower Bagshot. 8. London Clay and Bognor Beds. 9. Mottled Clay. 10. Chalk. 11. Middle Cretaceous. 12. Lower Cretaceous. 13. Wealden.

THE ISLE OF WIGHT.

[The first excursion to the *Isle of Wight* took place in 1864, under the guidance of Henry Keeping. A paper based on this excursion, by W. H. Leighton, may be seen in "The Geological and Natural History Repertory," No. 15, pp. 28-33 (July 1st, 1866). The second visit is reported below.]

EXCURSION TO THE EAST END OF THE ISLE OF WIGHT.*

WHIT-MONDAY, JUNE 6TH, 1881, AND TWO FOLLOWING DAYS.

Directors.—Prof. J. MORRIS, F.G.S., F. G. H. PRICE, F.G.S., and E. B. TAWNEY, F.G.S.

(Report by E. B. TAWNEY.)

(Proc. Vol. vii. *p.* 185.)

THE party arrived at Portsmouth by the mid-day train and forthwith took passage in the steamer for Ryde. From hence a short railway journey brought them to Brading Station, whence they proceeded to the Roman villa. A printed account of the discoveries was given to each member, while Mr. Price conducted the party round the works, explaining the plan of the original building, pointing out the mosaics in the different rooms, the hypocaust, &c., and finally the well, which had just been re-excavated.

Returning to Brading Station the members found awaiting them the little train which had been sent for them by Mr. R. B. Grantham and Mr. H. S. Freeman, the Consulting and Resident Engineers of the Bembridge Reclamation Works, where, on arrival at the Harbour Works, the points of interest in the scheme, by which a great tract of land is being drained and reclaimed, were pointed out. The new sluices, which were near completion, were examined.

The party then walked along the bank which has been built to form the sea-wall to Bembridge Hotel.

WHIT-TUESDAY.—Mr. Freeman having kindly put his steam

* A new edition of the Geological Survey Memoir on the Isle of Wight, revised and enlarged by Clement Reid, F.G.S., and Aubrey Strahan, M.A., is now published. A new edition of the Survey map has recently been issued.

FIG. 101.—SECTION OF WHITECLIFF BAY (after Prof. J. PRESTWICH), SHOWING VARIOUS CLASSIFICATIONS OF THE BEDS.

Geol. Sur. — Woolwich & Reading Beds. | London Clay. | Lower Bagshot. | Bracklesham Beds. | Barton Clay. | Upper Bagshot. | Lower Headon | Middle Headon | Upper Headon | Osborne or St. Helens. | Bembridge Limestone.

FLUVIO-MARINE SERIES.

LOWER EOCENE. ... MIDDLE EOCENE. ... UPPER EOCENE.

J. S. Gardner — London Clay. | Lower Bagshot. | Bournemouth Fresh-water Beds. | Bournemouth Marine Beds.

Bracklesham Beds of Rev. O. Fisher.

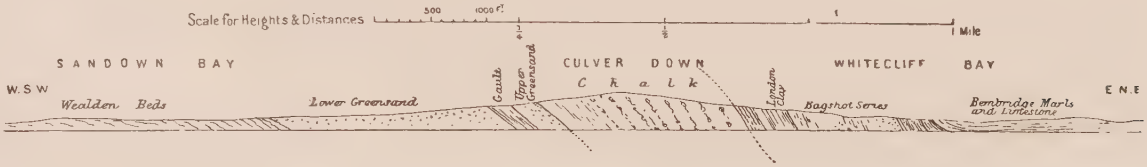
Prof. J. W. Judd — Headon Group (Estuarine). | Brockenhurst Series (Marine). | Lower Bembridge Marls. | Bembridge Limestone.

LOWER OLIGOCENE. MIDDLE OLIGOCENE.

A. Horizon of Plant-beds in Alum Bay.
B. „ „ at Bournemouth (Gardner).
C. „ Crustacea and Insects at Gurnet Bay.
P. Lines or Beds of Pebbles.

The chief Beds of Sand are shown by dots.
The numbers of the Beds are those used by Prof. J. Prestwich (Quart. Journ. Geol. Soc., vol. ii., plate ix., fig. 2.

FIG. 102.—SECTION FROM SANDOWN BAY TO WHITECLIFF BAY.



yacht at the disposal of those who preferred a sea voyage to a walk on foot to White Cliff Bay, some members availed themselves of his offer.

The party then observed the coast section. Beginning at the east end of the bay the Chalk is seen forming the headland of Culver Cliff, and is rather inaccessible on this side. Lying against the Chalk, with the beds at first nearly vertical, are the mottled clays of the Woolwich series, without fossils. Next is an interesting conglomeratic bed of flint pebbles, together with a greenish-brown sand, in which *Ditrupa plana* is abundant. Then comes the London Clay. Succeeding the London Clay is the Lower Bagshot series, in which a mass of fragments of leaves is seen at one spot, but nothing entire was obtained. The Bracklesham beds are fairly fossiliferous in places, as described by Osmond Fisher (Q. J. G. S., vol. xviii. p. 65); but there was not time for the collection of these fossils, which, when obtained, are so difficult to preserve. In the Barton Clays nothing was found; nor could the party collect anything from the yellow sands of the Upper Bagshot, though officers of the Geological Survey here found casts of *Cardium* and other marine shells. Above the Upper Bagshot Sands were seen the fresh-water clays of the Lower Headon, in which ordinary fresh-water univalves are abundant; over these are occasional lignite beds a few inches thick.

Lying on the eroded surface of the green fresh-water clays are marine beds of the Middle Headon; the lowest two feet being known from Fisher's paper to contain the Brockenhurst fauna, *i.e.*, the same fossils that occurred in such abundance in the railway-cutting in the New Forest in a bed only one foot thick.

Above this bed fossils became scarcer, but some fourteen feet higher up is a rich band in the Middle Headon containing abundantly *Cyth.rea incrassata*, *Cerithium pseudocinctum*, and other fossils characteristic of the same beds at Headon Hill, many of which were obtained. After the Middle Headon there is a change again to fresh-water conditions in the Upper Headon, and the thin limestones near the top, crowded with fossils, attracted attention. These are succeeded by the mottled red and greenish clays of the Osborne series, which are apt to be grassed over in the cliff, but can be seen on the shore.

More attention was paid to the Bembridge Limestone, of which massive blocks strew the foreshore; it is a cream-coloured and often concretionary limestone, and contains *Limnæa* and other fossils.

FIG. 103.—CONTINUOUS SECTION FROM COLWELL BAY TO HEADON HILL.

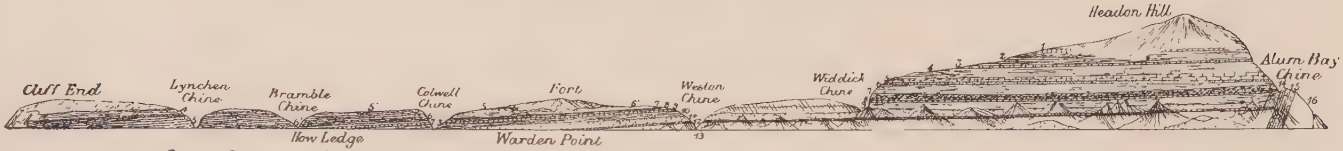


FIG. 104.—SECTION AT ALUM BAY CHINE.

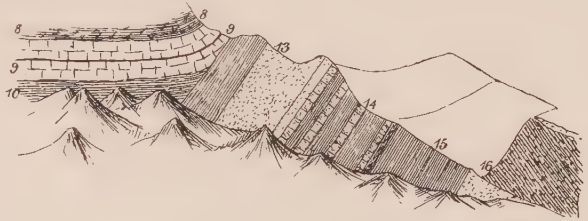
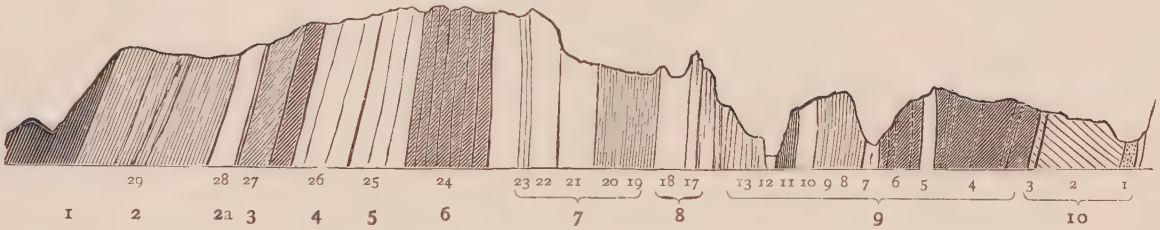


FIG. 105.—SECTION AT ALUM BAY.



The small numbers refer to the nomenclature of the Beds according to Prestwich (Q. J. G. S., 1879, p. 226); the large, according to Gardner (Proc. Geol. Assoc., vol. vii., 1879, p. 102). The latter are given here.

1. Barton. 2. Upper Bracklesham and Highcliff Sand. 3. Hengistbury Head Beds, with Ironstone. 4. Hengistbury Head Beds, with green grains. 5. Boscombe Sands. 6. Bournemouth Marine Series. 7. Bournemouth Fresh-water Series. 8. Lower Bagshot. 9. London Clay. 10. Woolwich and Reading.

The walk over the rest of the series round by the Foreland was resumed. The most fossiliferous places on the foreshore for the Bembridge Marls were still covered by the tide. However, the thin marine *Ostrea vectensis* band near the base, about five feet above the Bembridge Limestone, was well seen in the cliff. The Gravel of the Foreland had been examined nearer Bembridge.

Wednesday.—In the morning the party walked to Sandown Bay, by the Granite Fort, to examine the Wealden beds, the Neocomian and succeeding beds up to the Chalk.

At the top of the Wealden series the Perna bed was found, *i.e.*, loose blocks of it were seen lying about, owing to the tumbled state of the Wealden cliffs. Mottled red beds occupy the shore for some distance; then the grey shales succeed, and these are rich in *Cypridea valdensis* towards the top, while interstratified with them are limestones showing a brackish-water condition, containing a dwarfed oyster, a small *Modiola*, *Cyrena media*, &c., as on the Atherfield coast.

Except in the Perna bed no fossils were found in the Neocomian, though a great thickness is exposed under Redhill Battery, consisting of grey sandy clays, yellow and brown sand rock, &c.

Above the Neocomian follows the dark grey Gault clay; but neither the upper nor lower junctions of this clay are well seen now, and no fossils were found. The Upper Greensand seems to pass insensibly into the Gault, and the micaceous marls and sandstones at the base are poor in fossils. The glauconitic sandstone above has the true Upper Greensand character, and the fossils are more abundant. The Chloritic Marl here can scarcely be made into a separate division, phosphatic nodules and fossils being the same as in the Greensand.

There was no time for working further round the point. Indeed, the Chalk can only be examined at low water, or in fallen blocks.

A return was made up the zigzag path which leads past Redhill Battery, and so by Yaverland Manor House back to Brading.

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New Ordnance Survey. Sheets 330, 331, 344, 345. 1*s*. each.

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J. S. Gardner, The British Eocenes and their Deposition. Proc. Geol. Assoc., vol. vi., 1879, p. 83.

J. F. Blake, On a Continuous Section of the Oligocene Strata from Colwell Bay to Headon Hill. Proc. Geol. Assoc., vol. vii., 1881, p. 151.

[See also References to Hampshire Coast, p. 296.]

[On April 22nd, 1886, a considerable number of members visited *Southampton*, inspecting various places in the immediate neighbourhood on the following day (Good Friday), and on Saturday the new railway from *Brockenhurst* to *Christchurch*. W. Whitaker was Director. On Saturday evening the party left for *Salisbury*. For a report see Proc. vol. ix. p. 522. *Southampton* was again visited on April 7th, 1887, the neighbourhood of the new *Southampton Waterworks*, and the new railway between *Netley* and *Fareham*, being explored. On Saturday evening the party left for *Bognor*, Mr. Whitaker again directing. The following Monday (Easter) and Tuesday were spent at *Brighton* and *Newhaven*, under the guidance of Henry Willett and W. Topley. See Proc. vol. x. pp. 132-144.]

SOUTH-WESTERN COUNTIES.

DORSETSHIRE AND WILTSHIRE.

[The first excursion to *Swindon* occurred in 1865; no report of it appears to exist. Another, to *Stroud*, *May Hill*, and *Swindon*, is briefly recorded in Proc. vol. ii. pp. 33-34. About ten lines are devoted to Swindon. A third, to *Swindon* and *Faringdon*, took place at Whitsuntide, 1876; that part of the report dealing with Faringdon is given with the excursions to Berkshire, while below follows the account of the visit to Swindon.]

EXCURSION TO SWINDON.

June 5th (Whit-Monday), 1876, and Following Day.

Directors -Professor John Morris, F.G.S., Charles Moore, F.G.S., and E. C. Davey, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 543.)

On arrival at Swindon Mr. Moore led the way to the brick-pits S.E. of the G.W.R. Station, which have yielded the magnificent remains of *Omosaurus armatus*, *Bothriospondylus suffossus*, and *Pliosaurus brachydeirus*, figured by Professor Owen in his British Fossil Reptilia. At the period of the visit about twenty feet of beds were exposed, a portion of the Upper Kimeridge Clay. Such remains as those alluded to are not often found, and the pits did not yield many fossils; a small form of *Astarte ovata* is one of the most common shells, together with an *Ostrea* (*O. expansa?* Sow.), in several stages of growth. There are plenty of impressions of *biplex* ammonites, but belemnites are said to be rare. The character of this formation is further disclosed by a fresh cutting on the north side of the steep hill on which Old Swindon stands, though the junction with the "Portland Sands" is a little obscured by the sliding forwards of the upper beds.

The Kimeridge Clay* seen here is perhaps sixty or seventy feet above any worked in the brickyards, and contains hard, concretionary bands, dipping southward into the hill at a considerable angle. *Ammonites biplex*, *Cardium morinicum*, *Thracia depressa*, &c., were noted.

The town of Old Swindon is built on the flat top of a detached eminence, which forms part of an imperfect chain of heights marking the outcrop of such remnants of the uppermost Jurassic rocks as had escaped denudation in this part of England previous to the deposition of the Lower Cretaceous (Neocomian) series. These uppermost Jurassic rocks, usually known as Portlandian and Purbeck beds, have been wrought for a long time in vast quarries on the south-west side of the town. To these quarries the members were conducted. The following announcement of what was seen then is extracted from the circular. "PURBECK BEDS.—Fresh-water Marls and Limestones, 10 feet thick, with depressions containing material from the Lower Greensand. Mr. Moore will exhibit from these beds an interesting series of remains, including *Plagiaulax*, *Spalacotherium*, and other mammals. *Macellodus Brodei*, *Nuthetes*, *Goniopholis crassidens*, the tooth of a megalosauroid reptile, apparently allied to the *Cetiosauri*, and other reptilian remains—*Batrachia*, including the oldest known true frog—together with fruits and seeds, and some of the Mollusca of the period."

Mr. Moore pointed out to the members the principal features of the general section and gave a brief description of the results he had obtained by a careful observation of the beds during a period of fifteen years. "Four distinct formations might here be noted. 1. The pipe-like veins atop filled in with *remanié* Lower Greensand. 2. The Purbeck Beds. 3. The Portland Rock. 4. The Portland Sands (which yield the Swindon Stone).† In the quarry generally the Swindon Stone is of an intermittent character, there being, towards the base, layers of loose material, with bands of nodules and continuous beds of rock. These are succeeded by a series of chalky-looking limestones, in which may be observed one or two darkish bands, something akin to the dirt beds of the coast districts. These black bands are earthy carbonaceous

* These beds are really Portlandian, as Mr. Hudleston would doubtless now admit. See J. F. Blake, Quart. Journ. Geol. Soc. vol. xxxvi. pp. 208, 211-213. H. B. W.

† The so-called Portland Sands here represent the lower part of the Portland Stone, and the Sands are beneath.—H. B. W.

marls and loose sandy beds and they contain a remarkable mixture of marine (? derived.—H. B. W.) and fresh-water forms. The whole of this series is referred to the Purbecks, but the chalky limestones or marls contain few remains of a recognisable character. Hitherto no Mammalia had been quoted from the Purbeck beds of Swindon, but now this void had been filled up. He might mention also *Paralestes* in addition ; and to the list of Reptilia he would add *Saurillus*. Of fishes there was *Lepidotus*, and peculiar forms with very small teeth, but it must be admitted that the remains were often fragmentary and difficult of identification, everything vertebrate having been much washed about. As regards Batrachia none were known between the Purbecks and the Tertiaries ; yet he could not doubt that the specimens secured from these beds were authentic and that they really belonged to the period in question, their mineral condition being precisely that of the other fossils, about which there could be no question. Respecting plants, there was much trace of vegetable matter in these black bands. He had made out the seeds and stems of at least two species of *Chara ;* nor could he be mistaken in assigning to the dock tribe certain specimens showing the capsule, with the seed peeping out from it, the mineral condition of which could leave no reasonable doubt as to these specimens of a dicotyledonous plant—unique, as far as our present knowledge goes, at that early age—being really contemporary with the other fossils. Of Mollusca, *Planorbis*, *Hydrobia*, *Valvata*, *Physa*, *Nerita*, *Trochus*, *Limnæa*, *Dentalium*, *Cerithium*, *Ostrea*, *Cytherea*, *Arca*, were amongst the singular mixture of marine and fresh-water forms which these black bands contain. Of Ostracoda he had obtained four or five species of *Cypris ;* two forms, possibly two distinct genera of Polyzoa ; *Pentacrinites ;* rarely the spines of an Echinite ; *Nodosaria* and *Flabellina* amongst Foraminifera ; and finally coprolites and derived pebbles. The question naturally arises, to what stage of the Purbecks, as exhibited in the Swanage district, should these beds be referred ? There are at Durlston, or Durdlestone, between 200 and 300 feet of beds. On the whole he was inclined to refer these to the Middle Purbecks, though the series, as here developed, may have been the result of currents cutting out and modifying beds previously deposited."

Mr. Moore concluded by stating that, whereas the Geological Survey, in their published Memoir, enumerated no more than seventeen species from the Purbecks of Swindon, he had been able to

add eighty species to the list. Some of these treasures he proceeded to exhibit as vouchers for what he had already stated. The bones of the "oldest known true frog" were scrutinised, but no material difference in its mineral condition, whereby it could be distinguished from other associated remains, was detected. A small phial full of the teeth of *Macellodus* was exhibited, some of the specimens being much larger than any hitherto figured. Specimens of most of the genera above enumerated were also exhibited.

Professor Morris briefly alluded to the physical history of the formations of this immediate district.

"The Portland beds, being the latest of all the Oolites, are seen to rest on the Kimeridge Clay, and in some cases, as at Aylesbury, there is a band of dark pebbles marking the base of the stone. These Portlandian beds form the third and least important, because most irregularly developed, of the four great lines of escarpment which occur in this part of England, viz. (1) the Cotteswold or Lower Oolite escarpment; (2) the Corallian, most marked in the ridges of Wootton Basset and Highworth; (3) the Portlandian, on which we now stand; and (4) the Chalk escarpment which may be seen closing in the landscape on the south. Referring to the development of the formation, the hard tabular limestones of the Isle of Portland are again met with at Upway (near Dorchester), and also in the Vale of Wardour, at which place they are associated with a considerable development of the Purbeck beds. Proceeding north, however, the character of the Portlandian series is more sandy and uncertain, and the Purbecks, too, show a corresponding diminution, as at Shotover, near Oxford, where the Portland limestones (as such) are altogether absen and the Purbeck beds have gone out with them, although on the southern part of the hill they are both seen at Combe Wood and Garsington. The Portland beds may be further traced at Thame, Brill, and with the overlying Purbecks at Hartwell and Whitchurch, near Aylesbury, beyond which there is no further exhibition of Portlandian beds in England, excepting a small and doubtful development at Speeton, in Yorkshire. It was evident that during the deposition of this series there was a gradual uprising of the Oolitic area, producing a tendency to brackish-water, and finally, even, in some places to fresh-water, conditions. He had great pleasure in bearing witness to the interesting and suggestive nature of Mr. Moore's discoveries in connection with these partially fresh-water beds, and in answer to his question

as to what portion of the Swanage Purbecks they represented he ventured to suggest that they might be the equivalents of the entire thickness (300 feet) there displayed. With regard to some of the genera occurring in these kinds of beds he alluded to the presence of *Corbula*, in true Purbeck strata of marine character, at Wimereux in the Boulonnais, and in the Purbeck at Pounceford in Sussex, as well as at Swindon. There are species of *Arca*, too, which are capable of living under fresh-water conditions.

"The last formation in the quarry which required notice was the Lower Greensand, here only existing in an imperfect and *remanié* condition. But in this district the various Oolites are transgressively covered by some members of the Neocomian series. At Seend, for instance, we have the marine shells of this period in a ferruginous grit, resting upon Kimeridge Clay, whilst in the opposite direction the party would observe to-morrow, at Faringdon, the Kimeridge Clay and Coral Rag, covered by the remarkable Sponge Gravel, now well known to belong to the Lower Greensand. At Shotover and at Hartwell the Portland series is capped by beds containing *Unio*, *Cyclas*, and *Paludina*, pointing to fresh-water conditions, but still of Neocomian age. All this would seem to indicate that the old land surfaces, disclosed in the interval (represented by the Wealden and its equivalents, the Lower and Middle Neocomian) which bridges over the Oolitic and Neocomian periods were still in existence when a portion of these latter began to be formed. Ultimately a depression, marking a stage of the Neocomian period, set in, and a great and unequal erosion of beds of various ages was accomplished. In the hollows and gullies thus formed the pebbly Lower Greensand (Upper Neocomian) of this region was deposited and in this way it came to be transgressive over so many formations."

The Portland beds, as pointed out by Mr. Moore, were observed to consist of impure gritty limestones, intercalated between looser sands, the latter predominating towards the floor of the quarry. Calcareous casts of *Ammonites giganteus*, *Trigonia gibbosa*, *Cardium dissimile*, *Cytherea rugosa*, &c., are plentiful enough, just as in the Isle of Portland itself. Towards the east end of the quarry the so-called Purbeck beds overlie the Portland beds in considerable force and the black carbonaceous friable loam, in which Mr. Moore has found so many fossils, is well developed at this point. Further on the same bed was observed to be a mass of *Cerithium portlandicum*, the shell itself (not the cast) being preserved in a dark friable marly grit.

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EXCURSION TO SALISBURY, STONEHENGE, AND VALE OF WARDOUR.

Easter Monday and Tuesday, April 18th and 19th, 1881.

Directors—W. H. Hudleston, F.R.S., Dr. John S. Phené, and Dr. H. P. Blackmore.

(*Report by* W. H. Hudleston.)

(*Proc. Vol.* vii. *p.* 134.)

The party arrived at Salisbury and soon found their way to the Blackmore Museum. Some of the members took the opportunity of visiting the cathedral, which, as a piece of masonry, built of the stone of Chilmark and Tisbury, is in every way worthy the attention of geologists. The carving on the west front has recently been renewed with stone said to come from the uppermost Portland beds of Chilmark. The rest of the building is for the most part constructed of the lower building stone and its very good state of preservation, considering the date of its construction, bears ample testimony to the excellent quality of the stone. The columns in the interior are of unpolished Purbeck marble, with polished shafts of the same; the latter are, in some cases, bent by pressure and have required considerable repairs. The spire is said to be slightly deflected from the perpendicular, to the extent of about one foot measured on the floor, and has been in this condition for a very long period.

Dr. Blackmore, who received the party, gave a demonstration on the mammalian remains from the low-level gravels of Fisherton and Bemerton which are preserved in the Museum. This Museum was founded in 1864, by the late Mr. William Blackmore, of Liverpool and London.

The general arrangement is as follows:—Group I. Remains of animals found associated with man. Group II. Implements of stone. Group III. Implements of bronze. Group IV. Imple-

ments, &c., of modern savages, serving to throw light upon the use of similar objects belonging to prehistoric times.

The remains of mammalia are mostly from the lower gravels underlying the brickfields at Fisherton, about a mile to the west of Salisbury. These consist of bones or teeth of *Hyæna*, *Felis*, *Canis lupus*, *Spermophilus*, *Lemmus*, *Elephas primigenius*, *Rhinocerus tichorinus*, *Cervus tarandus*, *Bison priscus*, *Bos primigenius*, *Ovibos moschatus*, &c.*

In the brick-earths of the same locality are found such fresh-water shells as *Ancylus fluviatilis*, *Limnæa palustris*, *Planorbis carinatus*, *Bithynia tentaculata*, *Pisidium fontinale*, &c. ; and such land shells, as *Succinea putris*, *Pupa muscorum*, and several species of *Helix*.

The collection of flint implements is most extensive; no pains or expense has been spared to make it as complete as possible. The chief interest here may be said to centre in the collection of the Palæolithic period, and especially of the Drift series, from the neighbourhood of Salisbury, both on Milford Hill and on the hill which divides the Avon and Wiley Valleys above Bemerton. But besides these are implements of the Cave series from other districts. The implements of the Neolithic period are also abundantly shown and there are collections illustrative of the lake dwellings of Switzerland, &c., and of the shell-mounds of Denmark, besides a most wonderful series both from North and South America.†

Amongst the curiosities is a collection of forgeries, together with an excellent photograph of that arch-forger, Flint Jack, who was perhaps even better known at Salisbury than in his native Yorkshire.

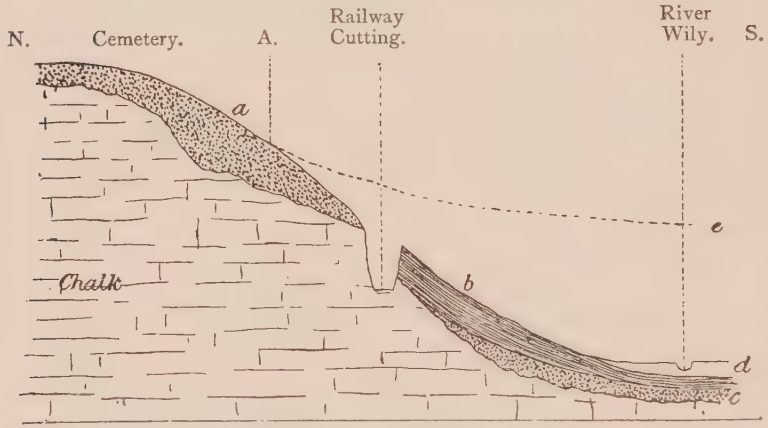
After a most exhaustive demonstration of these treasures by the Director the party adjourned to Milford Hill, about one mile N.N.E., where excavations for the foundations of houses were disclosing sections of the high-level flint-bearing gravels. These consist of a brown clayey flint gravel, in which, for the most part, the implements are found, resting sometimes on a light-coloured and more sandy deposit, sometimes directly on the chalk itself. Several implements have been taken quite recently out of these beds.

* Woodward and Sherborn, Brit. Foss. Vert. 1890.

† The Salisbury and South Wilts, and Blackmore Museums are in St. Ann Street, Salisbury. The current expenses are defrayed by annual contributions.

It was found impossible to carry out the entire programme, involving a visit to the deposits at Fisherton and Bemerton. As this section is of considerable interest and importance it is given below:—

FIG. 106.—SECTION AT FISHERTON.



Length of Section, about 250 yards.

a. High-level quaternary gravel, containing palæolithic flint implements, but no organic remains.

b. Brick-earth, containing land shells with few mammalian remains. Two or three flint implements.

c. Low-level quaternary gravel, which has yielded the principal part of the mammalian remains, and a very few flint implements.

d. Alluvium.

e. Contour of ancient valley 80 feet at A.

A tolerably punctual start was made for Stonehenge, distant nine miles N.N.W., and the first halt was at Old Sarum, a commanding point on the east side of the Avon, about two miles north of the present city. The following notes, prepared by Dr. Phené, were read by the President.

"Old Sarum was originally a British fortress, and was taken by the Saxon Kenric in 552 (skeletons recently disinterred on Milford Hill are evidences of some of the fighting). Alfred the Great strengthened it. In 960 Edgar held a council of the nation to oppose the Danes. In the reign of Ethelred II. Sweyn took it. William the Conqueror founded the see, which was formerly that of Sherborne and Castleton, and held here his grandest council, as did William II. in 1096, and Henry I. in

1116. It was deserted by Henry III., as being deficient in water, and the see was removed to New Sarum (Salisbury) in 1219. Some houses remained in the reign of Henry VIII. It is said that here was a palace of the British and Saxon kings, and of the Roman emperors. The donjon mound is now the principal object. The old city appears to have been built entirely on the artificial British hill."

Once more the party betook themselves to the dusty road which traverses the plateau between the valleys of the Avon and the Bourne, and presently arrived at Amesbury, whence the direction became due west. The Avon was crossed, and the remarkable earthwork known as Vespasian's Camp sighted. Shortly after this the road emerges upon the treeless and lonely plain, where the mystic ring of Stonehenge seems yet to invite the archæologist to explain its origin. The Director (Dr. Phené), who had approached with a party of friends from the direction of Devizes, then read his promised address, "On the origin of Stonehenge, the various periods of its construction, and its connection with Roman works."

There are *four* kinds of stone used in the monument. The outer ring is composed of huge *Sarsens*—a compact quartzose rock, derived from the Tertiary Sands. These are, in fact, siliceous doggers or concretionary slabs of enormous size, which have hardened *in situ*, and have resisted the atmospheric agencies of destruction. Several fragments were picked up of this material, which seemed to bear the marks of roots or something of the sort. It is by no means improbable, therefore, that the decomposition of vegetable matter, and consequent formation of *humus*, and the various organic acids which arise from its gradual alteration into carbonic acid, may have had something to do with the concretionary action. The influence of these organic acids on silica has been the subject of interesting investigations in America.

The *second* variety of stone has only one representative, *viz.*, the "altar stone." This is described as a grey sandstone, composed of quartz sand, silvery mica, and some dark grains. It is, in fact, a micaceous grit, and might possibly have been brought from the Old Red Sandstone of the Mendips near Frome. It much resembles the stone beneath the Coronation Chair known as the Scone stone.

The *third* variety, which comprises the bulk of the inner circle, includes twenty-nine of the smaller stones. To these the term greenstone, and even "syenite," has been applied; the latter

name because augite was mistaken for hornblende. Prof. Maskelyne describes these, generally, as consisting of a white or greenish-white felspar, with broad crystals of brown and sometimes greenish augite. The felspar is probably labradorite ; this is clouded and suffused with chlorite. The rock may fairly be called a diabase, though its mode of occurrence points to the possibility of the chlorite being contemporaneous. The augite is less decomposed. Magnetite and quartz are also present. The ground mass is sparse, but contains fine crystalline grains, some of which may possibly belong to a different felspar. As a specimen of their chemical composition, No. 4 afforded—

Silica	51·7
Alumina	12·1
Iron Oxides	15·3
Lime	10·0
Magnesia	4·08
Potash	1·02
Soda	2·80
Water (? Carb. Acid)	2·60
	99·6

The augite occurs porphyritically throughout, but in this specimen is more compact than in some, and the felspar in better order. The chlorite sometimes occurs in distinct triangular places ; and quartz crystals are also present, giving evidence of secondary action due to the crystallization of progressively dissociated silica.

The *fourth* variety has only four representatives. No. 9 is a siliceous schist, Nos. 11, 17, and 19 are hornstones, with specks of felspar and pyrites. These may be described as a variety of sedimentary and somewhat metamorphosed rock. The stones are harder than quartz, and have a sp. g. of 2·7 to 2·8. The general aspect is that of a triturated igneous rock, the materials of which have been redistributed by aqueous action ; the fundamental character is that of a fine-grained mixture of quartz, felspar, and a grey chloritic mineral. They have a remarkable structure somewhat schistose. This arises from the quantity of chlorite, which is endogenous, whilst the other crystalline particles are elastic, and therefore exogenous.

In No. 17 there is magnetic pyrites, whose decomposition stains the rock. No. 19 afforded—

Silica	77·4
Alumina	13·5
Iron Oxide	3·5
Lime	1·8
Magnesia	1·3
Potash	0·60
Soda	0·73
Water and loss	1·30
	100·13

Professor Maskelyne observes, with regard to the so-termed fluxional character, that it is by no means an uncommon feature in this class of sedimentary rock, built up out of the materials of the old igneous rocks, where the ground-mass may be observed in wavy lines round the uncrushed fragments and crystals. Similar rocks occur in the Cambro-Silurians of Wales and Cumberland, especially some described as volcanic ash, though none of these are volcanic ash in the usual sense of that term.

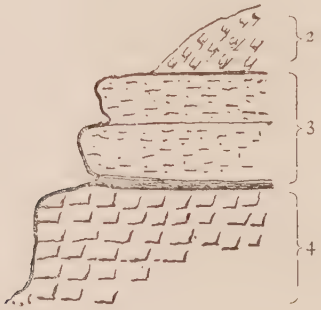
Tuesday.—About 10 a.m. rail was taken for Tisbury, about thirteen miles to the west. Shortly after moving out of the station the train passes through the cutting shown in the Fisherton section, and thence proceeds up the Wiley valley to Wilton. Here the Wiley is joined by the Nadder coming from the west, and the line follows the valley of the latter, and may be said to fairly enter the Vale of Wardour near Barford, where the Upper Greensand is seen dipping to the eastward below the Chalk at a considerable angle. The station at Dinton is built on the attenuated representative of the Neocomian beds, which are rapidly dying out to the westward; and beyond this, for some distance, the more important cuttings are in the Purbeck beds. There is no cutting which gives a good section of the Portland beds, though the line must run through the entire series down to the Kimeridge Clay, over which the Nadder flows at Tisbury station. Here the party left the train, and Mr. Hudleston distributed among the members a number of pieces of Portlandian Coral *(Isastræa oblonga)*, which is known in this district as "star-flint," being always found in a silicified condition. The specimens occur in the lower building stone series (No. 4 of the Chilmark section), and are found, not exactly *in situ*, but in a disintegrated deposit formed by the surface weathering of this series on the high ground to the N.W. of Tisbury. Curiously enough it has never been detected in the equivalent of this series to the eastward.

Avoiding the town of Tisbury the party made for Place House, situated at the junction of a stream from Fonthill with the Nadder. By the kind permission of Mr. Brasher the party were permitted to inspect the curious old barn and other buildings, which at one time belonged to the Wardour estate, and were erected by the people of Shaftesbury Abbey.

Climbing up the steep hill above Place House the party passed an old quarry in the Portlands, from which the stone is now cut up by saws elsewhere. Thence the high ground of Ladydown was gained. The view from here is extremely fine, and the stratigraphical features of the Vale of Wardour impress themselves strongly on all who take an interest in physiography. The Director explained the topography of the district and the geological relations of the beds which compose it, dwelling especially on the subject of the anticlinal, and its relation to similar physical features elsewhere. This done, the members moved on, reaching an opening in the Purbeck beds, where Mr. Meÿer found a small fish.

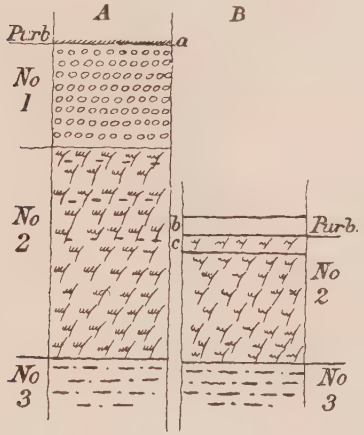
The so-called Chilmark Quarries are situated in a ravine, drained by a stream flowing at right angles to the axis of the anticlinal. This natural ravine has been further enlarged, and its sides roughened, by the excavations of centuries. The east side

FIG. 107.—SECTION OF PORTLAND STONE AT CHILMARK. [Hudleston.]



2. Base of the Chalky series.
3. Ragstone or *Cyrena* beds, divided into two blocks, of which the lower weathers into shell tablets. Between this and 4 is a soft, brashy bed with wood.
4. Building Stone series.

FIG. 108.



A. CHILMARK QUARRY.—*a*. Dirt bed. 1. Upper Building Stone. 2. Chalky Series. 3. Ragstone or *Cyrena* beds.

B. CHICKSGROVE MILL QUARRY, 1¼ MILE S.W.—*b*. Lowest Purbeck bed. *c*. Highest Portland bed, cemented into one block, which projects over 2. [Hudleston.]

is in Teffont parish, and the rector, the Rev. W. R. Andrews, assisted the Director in many ways. The following is an extract from the Circular, with reference to these quarries :—

"Junction of the Purbeck and Portland Beds well seen on the east side. A. Purbeck Beds. B. 1. Highest beds of the Portland series; 2. Chalky series with flints; 3. *Cerithium* and *Cyrena* beds; 4. Main building stone, a sandy limestone. Group 3 is very fossiliferous, and the shells well preserved."

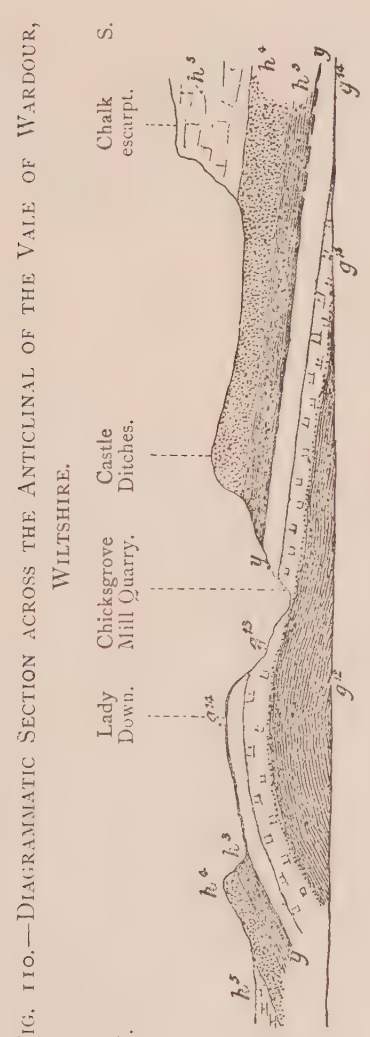
Each group was taken in order, beginning with the highest. The flint in the chalky series attracted much attention, being both vertical and horizontal in its mode of occurrence. A rather fine crustacean was found at the base of the chalky series, and a very large specimen in flint of *Avicula modiolaris?* The *Cyrena* beds, as usual, yielded the bulk of the fossils.

Chicksgrove Mill Quarry was next visited. The junction of the Purbeck and Portland beds occurs here under totally different circumstances, which the Director and Mr. Andrews took care to point out. Only a portion of the members went as far as Wockley Quarry, and finally the party reassembled at Tisbury station to leave by the train, going eastward.

FIG. 109.

VALE OF WARDOUR
Scale 2 inches to 1 mile.
Reduced from the Geological Survey Maps
Chalk
Upper Greensand
Gault
Hastings Sand
Purbeck Beds
Portland Beds
Kimeridge Clay
Cretaceous
Neocomian
Upper Jurassic
Line of Section
Shaftesbury
Wilton
Barford
Barford Heath
Fovant Hill
Chisledunbury Hill
Duntish Hill
Buxbury Hill
Tisbury
Castle Ditches
Pyt House
Knighton
Stop Dole
Bishop's Ponyhill
Chalmark
Nadder Head
Knoll Down
Kingston Deverill
Hindon
Wardour
Ludwell
Ashmore
Ridge
Grey
Hill
Head

FIG. 110.—DIAGRAMMATIC SECTION ACROSS THE ANTICLINAL OF THE VALE OF WARDOUR, WILTSHIRE.



h^3. Chalk ; h^4. Upper Greensand ; h^5. Gault ; g^{14}. Purbeck ; g^{13}. Portland Stone, with some Sand towards base ; g^{12}. Kimeridge Clay ; y. Upper limit of Jurassic series.

[An excursion to *Salisbury* and *Stonehenge* took place on Easter Monday and Tuesday (April 26th and 27th, 1886), Dr. Blackmore and W. Whitaker being Directors. It is reported in the November number of the Proceedings for that year (vol. ix. p. 522).]

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Maps.—Ordnance Survey. Sheets 14, 15. 8*s.* 6*d.* each.
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P. B. Brodie, A History of Fossil Insects, 8vo, London. 1845.
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EXCURSION TO THE ISLE OF PURBECK.

Whit Monday, May 29th, and Following Day, 1882.

Directors—W. H. Hudleston, F.R.S., and Prof. J. Morris, F.G.S.

(*Report by* W. H. Hudleston.)

(*Proc. Vol.* vii. *p.* 377.)

First Day.—The members assembled at Wareham.

Wareham occupies a position of some importance between two rivers which unite immediately below the town, in the very centre of that inlet of the Hampshire basin known as the Trough of Poole. This trough consists of a synclinal of Tertiary beds lying in the fold between the Purbeck axis on the south and the Dorset downs on the north. These downs occupy a block of wild and elevated chalk country about nineteen miles in length between the gorge of the Frome at Maiden Newton and the gorge of the Stour at Blandford. They culminate in Rawlsbury, or Bull-barrow (Badbury Rings), said to be 927 feet above sea-level —a salient of the escarpment overlooking the Vale of Blackmore. The trough is closed on the west, as regards the Tertiary beds, by the curving round of the Chalk in the neighbourhood of Dorchester, so that, beyond this point, the Chalk area is very wide.

The Isle of Purbeck faces these northern downs. Strictly it should be described as a peninsula twelve miles in length from Worbarrow Bay on the west to Swanage Bay on the east, with a maximum width of about seven miles on the meridian of St.

Alban's Head. The neck of the peninsula is crossed by a line drawn from the head of Worbarrow Bay almost due north to the Frome at Stoke. The northern half of this peninsula is a dreary waste of Middle Tertiaries penetrated by innumerable creeks in connection with the tidal estuary of the Frome. The southern half is composed of Secondary Rocks inclined for the most part at a high angle, and may be said to contain nearly all that is of geological interest in the "Island." It is ruled off on the north by the highly tilted chalk ridge, and on the south presents its headlands, cliffs, and bays (formed entirely of Jurassic rocks) to the unquiet waters of the English Channel.

The distance from Wareham station to Corfe Castle is four and a-half miles, and as the latter town is approached the unique situation of the castle is more fully realised; but before entering the gorge the party stayed to inspect the workings in the Tertiary beds on the left-hand side of the road. For miles towards the foot of the chalk ridge the refuse heaps of these excavations for pipeclay seam the brown heath with a line of mounds, which, at a distance, might almost be taken for moraines. These beds belong to the Lower Bagshots, and are largely associated with the leaves of dicotyledonous plants. Mr. Brodie has also noted insect remains from this horizon.

The Matcham Clay Works, visited on this occasion, are on the opposite side of the road to the Nordon pits (indicated in the diagram), and present some unexpected features. In the first place the beds are dipping nearly due S. at an angle of 15°, being exactly the reverse of what the average inclination of the beds must be in this region, *i.e.*, they dip towards the longitudinal fault at the base of Knowl Hill.

Section of the Matcham Workings.

Black earth, and surface material, with flints indications of sepulture, &c. . . .	
1. Loose white sand with *Ironstone Bands* at base	20-40 ft.
2. Stiff yellowish or variegated clay—"pipeclay" .	30 ft.
3. Pure "Potter's Clay," with leaves, &c. . .	8 ft.
4. Lignite, or Brown Coal	2 ft.
Clay	

The loose sand is very full of water and exceedingly troublesome. The ironstone grits are very similar to those used for mending the roads hereabouts.

No. 2, the yellow or variegated clay, is taken off in large oblong

spits, and left in the workings. No. 3 is the article so much sought after; it is a soft, white, and somewhat unctuous clay and is no doubt pretty nearly pure kaolin. In the Nordon workings the lignite (No. 4) was sometimes found to be seven or eight feet thick, and was occasionally used as fuel by the workpeople.

From this place to Corfe Castle is only a few hundred yards. The great east and west fault once crossed, the indurated chalk is immediately seen dipping north about 70°. *Belemnitella* was noted in the highest beds, which are quarried for road stone. There are but few flints in these highest beds.

The two streams which have excavated the double gap in the Chalk ridge unite just below this quarry at about fifty feet above sea-level. The high road follows the most easterly of these gorges, having the curious insulated monticle on which the castle stands high upon the right. The members dismounted from the carriages and proceeded at once to climb the steep acclivity beneath the eastern ramparts of the now dismantled fortress. Towards the north extended the Tertiary plain just traversed, bounded in the far distance by the Dorset downs. On either flank were seen the deep gorges which separate the monticle from the rest of the Chalk ridge—Knowl Hill on the west, Challow Hill on the east. The area thus insulated may be about twenty acres in extent, measured at its base, sloping gently southward, that is, towards the town of Corfe Castle. So narrow is the outcrop of the Chalk here, owing to the high angle of dip, that already at the drawbridge the Upper Greensand is reached; the monticle itself, therefore, must consist of the Lower and Middle Chalk. There are no signs of any transverse disturbance or material change of strike; hence it is probable that the peculiarity of a double gap is simply due to the fact that the drainage of the longitudinal Wealden valley behind is effected by two streams which unite just outside the Chalk ridge. In all other respects the double gorge at Corfe may be regarded as analogous to those in connection with the Wealden of the south-eastern counties.

If archæologists are right the phenomenon of the excavation was recognised by the Anglo-Saxons in the name—originally Corvesgate, from the Anglo-Saxon *Ceorfan*, to cut; and truly it is one of Nature's most impressive cuttings, though small compared with some which might be mentioned. From early times this spot, which was in a certain sense the key to the Isle of Purbeck, had been the favourite resort of the Saxon princes.

At the Museum the Rev. Owen L. Mansel, of Church Knowle, gave a demonstration on the fossils and on the physical history of the district. This Museum was largely stocked by the late Mr. Brodie, of Swanage. It contains capital specimens of Purbeck fossils, including some insect remains, such as the wing of a dragon-fly, a few selected slabs with *Corbula*, *Cyrena*, *Unio*, *Melania*, etc., and many Turtle remains, including specimens of *Pleurosternum ovatum*, *Pl. concinnum*, described and figured by Prof. Owen; also ganoid fish and spines—*Asteracanthus*, *Hybodus*, etc.

There are likewise some interesting fossils from the Punfield beds and Lower Greensand, including several specimens of *Vicarya*, also *Ammonites Deshayesii*. Especially noteworthy is a species of lobster, said to come from below the marine band of Punfield Cove, and thus, according to Mr. Meÿer, showing the connection between these beds and the lobster beds of Atherfield.

Mr. Mansel particularly indicated specimens of marine shells obtained in a tufaceous deposit at no great distance from the town.

The route, after leaving the town of Corfe Castle, crosses the longitudinal hollow represented by the Wealden beds, and thence ascends the steep slope of the Purbeck beds to Kingston, which is situated on the Jurassic ridge forming the southern rampart of the isle.

The church of St. James is a remarkable building for so remote a village. It has been constructed at a great cost by the Eldon family from stone and marble procured on the estate. The marble for the pillars has been quarried from the *Paludina* beds of the Upper Purbecks at a place called Blashenwell (?). The stone for the outside has been obtained from the Burr beds of the same locality, out of quarries where there is a reversed or southerly dip. The Burr is a comminuted shell-limestone occurring at the base of the Upper Purbecks. The squared stone used in Corfe Castle is derived from the same beds. The interior mouldings of the church are made of Portland stone from a quarry about half-way between the village and Swyre Head.

This quarry, known as London Doors, was the next point inspected. It shows a very good junction between the Portland beds and the Purbeck beds, though somewhat different from any other junction. Being on the summit of the plateau, and situated

on the line where the northerly roll is becoming very pronounced, there is much curvature and infiltration. The irregularity of the junction, mainly produced by these two causes, could only be shown by a drawing. Moreover, the uppermost Portland bed weathers in such a way as to produce the most misleading appearances.

The Director made the following observations with reference to the Portland beds of the Isle of Purbeck. There are no *Cerithium* and *Cyrena* beds, such as the two well-marked series observed last year in the Vale of Wardour. In the Purbeck-Portlands all the beds belong to the purely marine type and are of great thickness. The Portland Stone is divisible into four principal groups, only two of which are well seen in this quarry.

GENERALIZED VERTICAL SECTION OF THE PURBECK-PORTLANDS.

	Approximate Thickness.
1. The topmost bed is a pure fine-grained limestone, usually quarried for lime-burning. It is sometimes compact or creamy; sometimes it weathers like chalk. The natives call this bed the "Shrimp," from the quantity of the remains of a small Crustacean. Parts of this are very fossiliferous, but there is usually no definite shell bed	9—10ft.
2. A huge Oyster bed with many species of Monomyaria, especially *Perna Bouchardi*. It has an irregular development. Is poorly shown in this quarry, but largely developed at Tillywhin, where the oyster bed forms the top of the Portlands	4—8ft.
3. The Oolitic series. At the Winspit quarries this contains two good tiers of freestone, each seven feet thick. It is most likely the uppermost of these tiers which is represented at London Doors quarry. Banks of *Trigonia gibbosa*, &c.	30—40ft.
4. The Cherty series, splendidly shown at St. Alban's Head	80ft.

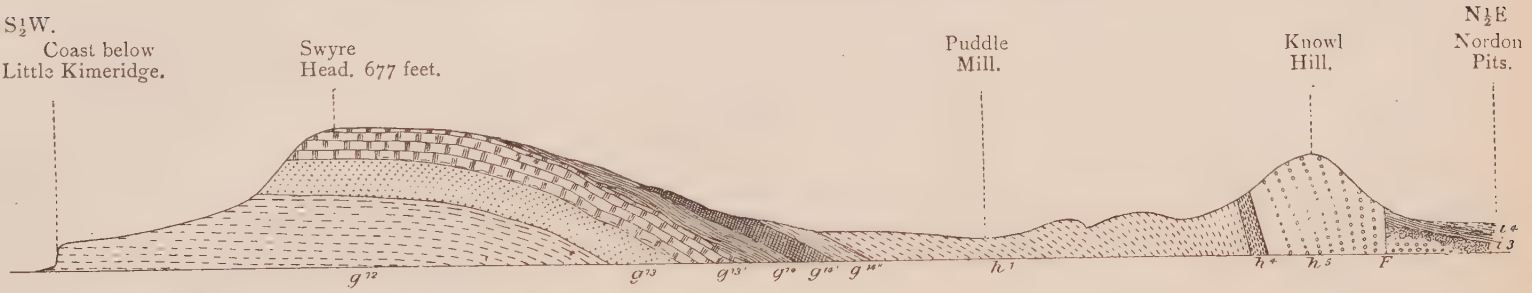
As the route along the plateau towards Swyre Head is resumed the great cirque known as the Golden Bowl suddenly appears to view on the left. This is a good specimen of those terminal

amphitheatres or horseshoes which show to more advantage in the Jurassic rocks than in any others. Skirting the edge of this cirque at an elevation of over 600 feet, with Encombe House and grounds deep in the hollow below, the party at length arrived on the level summit of Swyre Head, which is the highest point of the Portlandian escarpment—677 feet—and the citadel of the Isle of Purbeck.

Swyre Head.—The Head itself forms the southern termination of a promontory which projects from the Portlandian plateau, having on the east the deep bowl of Encombe and on the west the wider and nobler sweep of rock and grassy slope, at the bottom of which the little bay of Kimeridge reposes. This beautiful amphitheatre, facing the south, and cut off, as it were, from all the rest of the world, is remarkable for its fertility, due no doubt to the rich soil produced by the highly phosphatic Kimeridge Clay of this district mixing with the sand and lime of the overlying formations. An anticlinal, transverse to the main axis of flexure, traverses this hollow and brings up more than 100 feet of the Lower Kimeridge in the bay itself. It is not unlikely that something of the nature of a quaquaversal exist thereabouts, since from the hollow of Kimeridge Bay the beds dip west towards White Nore, north towards the Trough of Poole, and east, through Swyre Head, West Hill (terminating in Encombe Point), and Emmit Hill (terminating in St. Alban's Head), all the way to Durlston Head, six and a-half miles E. by S. of Swyre Head, where the beds, which are here nearly 700 feet above the level of the sea, plunge beneath it. The south-eastern corner of the Isle of Purbeck, including St. Alban's Head, is scarcely affected, therefore, by the chief or east and west axis of disturbance, its dips being in the main easterly. Thus a line drawn from St. Alban's Head to the centre of Weymouth Bay would pretty nearly follow the axis of the Weymouth-Purbeck anticlinal, where the beds in the immediate vicinity of the axial line are but little affected by it. As this line is for the most part about two miles out to sea the southern wing of the anticlinal is lost until we reach Weymouth Bay itself.

The curiously indented and highly tilted coast facing this axis is so much foreshortened, as seen from Swyre Head, that the effects of the very remarkable scenery of Worbarrow Bay, Mewps Bay, Lulworth Cove, &c.—all outside the Isle of Purbeck—are not fully realised from this point. Perhaps the most striking feature in the landscape is the abrupt ridge of Chalk which is stretched like a

FIG. 111.—DIAGRAMMATIC SECTION ACROSS PART OF THE MIDDLE OF THE ISLAND OF PURBECK. LENGTH OF SECTION RATHER OVER $3\frac{1}{2}$ MILES.



The line of this Section is about a mile west of the meridian of Corfe Castle, and strikes the coast half-way between Kimeridge Bay (west) and Chapman's Pool (east). The Upper Kimeridge alone is exposed, dipping eastward away from the anticlinal of Kimeridge Bay, which is transverse to the main axis of curvature. The beds on the Purbeck slope are more irregular than is shown in section. The thickness both of Purbecks and Wealden rapidly diminish towards the west, and this rule applies to all the beds below the Chalk.

FIG. 112.—SECTION ACROSS PART OF THE EAST END OF THE ISLAND OF PURBECK. LENGTH OF SECTION RATHER OVER $3\frac{1}{2}$ MILES.

REDUCED FROM MR. BRISTOW'S SECTION.

This Section is drawn a little inland of the actual coast, but so as to express its chief geological features. The fault in the Wealden (h^1) scarcely reaches the coast. The upper part of h^1 contains the "marine band," the "Punfield beds," and the uppermost "Lower Greensand." At the base of h^4 are dark clays, which represent part of the Gault. The fault which, at Knowle Hill, separates the Chalk from the Tertiaries, here passes through the Chalk itself. The junction of Chalk with Tertiaries is marked by a series of funnel-shaped pits, or "pot-holes."

EXPLANATION OF SIGNS.

g^{12}. Kimeridge Clay. g^{13}. Portland Sand. $g^{13'}$. Portland Stone. g^{14}. Lower Purbecks. $g^{14'}$. Middle Purbecks. $g^{14''}$. Upper Purbecks. h^1. Wealden or Hastings series. h^4. Upper Greensand. h^5. Chalk. i^2. Woolwich and Reading beds. i^3. London Clay. i^4. Lower Bagshots.

cord across the centre of the island and which may be traced from White Nore through Bindon Hill to Flowersbarrow, where the Isle of Purbeck commences. Next succeeds that portion of the ridge known as Purbeck Hill, lying N.W. of Swyre Head. Almost due north is Creech Barrow, quite 600 feet high, just outside the line of the chalk ridge. This rather singular hill is formed of Tertiary beds, chiefly the Lower Tertiaries, with a small capping of Bagshots, held up in a fork of the great longitudinal fault running on the north side of the chalk ridge. From this point the chalk ridge becomes lower in Knowl Hill, and continues to fall all the way towards the double gap at Corfe, whence it rises slowly through Challow Hill to Ninebarrow Down, where Cordington attains 654 feet—the highest point of the whole ridge.

One of the most interesting features to note is the steady lowering of the chalk ridge towards the double gap at Corfe, and then the sudden declivity of the double gap with the castle-crowned monticle in the centre. At the same time one cannot help noticing that the ridge has been pierced where it seems to form the head of a slight curve. This gradual falling-away of the chalk ridge towards the breach seems to point to long-continued erosion of some sort previous to the final excavation of the double gorge by the two streams which drain the central hollow. Doubtless the drainage area and consequent accumulation of water was greater formerly. The real dividing ridge of the island—the water parting—is the Jurassic plateau. All the waters falling on the north side of this parting, except such as flow into Swanage and Worbarrow Bays, must pass out at Corfe. Now the area draining into Worbarrow Bay is exceedingly small, and the basin of the Puddle Brook large in proportion; and it thus happens that this stream has done its work of excavating the western gap at Corfe much more effectually than the Byle Brook has in excavating the eastern gap. A reference to the map will show at once that the catchment basin of the Byle Brook is seriously interfered with by a low transverse (N. and S.) watershed, which directs much of the rainfall into the stream entering the sea at Swanage. When the land was more extensive a different state of affairs must have prevailed, and as regards the deep hollows on the south side of the water-parting, these seem to have formed the heads of valleys passing through a district which has been largely eaten up by the sea and is even now undergoing a rapid loss.

It became necessary to give up the notion of visiting the workings for "coal" on the cliff near Little Kimeridge, but the view towards St. Alban's Head and Emmit Hill was so inviting that a large portion of the members accompanied the Director in order to obtain a nearer view of the Kimeridge Clay and Portland Sand at those localities. The Upper Kimeridge of these parts is reckoned to be nearly 700 feet thick and is characterised by paper shales, bituminous shales, and cement stone beds of various qualities. These cement stone beds in their continuation out to sea form the Kimeridge ledges. The coal beds now worked are in the lower part of the Upper Kimeridge and consist of a block bituminous coal, two feet thick, and above this of a mass of bituminous shales, ten or twelve feet thick, but variable as to quality. Some of this coal contains a large amount of gas. One analysis gives 61 per cent. of volatile matter with a balance of 13 per cent. carbon and 26 per cent. ash. The gas has a high illuminating power, but smells horribly. It is generally supposed that the hydrocarbons have been distilled from the putrefaction of animal matter. The material occasionally has a market for the production of asphalte and other compounds. These Upper Kimeridge beds have a somewhat local development and have, on the whole, a different fauna from the Lower Kimeridge as exposed in Ringstead Bay. Palæontologically they are characterised by the absence of *Exogyra virgula*, *Ostrea deltoidea*, and *Rhynch. inconstans* and by the prevalence of *Lucina minuscula*, *Discina latissima*, and *Lucina lineata*. *Am. biplex* is very abundant.

A scrambling walk brought the party, after rounding the picturesque headland which terminates in Encombe Point, to the Kimeridge Clay of Chapman's Pool, a very noted locality for Upper Kimeridge fossils.* There was but little time for close search and the beds gave off an odour of sulphureted hydrogen, but a few of the more characteristic forms were noted and one or two tolerable specimens secured. Above the blue shaly clays of this place the bare slopes of Portland Sand are seen to be surmounted by the cherty calc grits which form the base of the Portland Stone capping the precipices of Emmit Hill, &c. This Portland Sand is a strange mixture of clay, sandy clay and hard bands, so that few authors agree as to the thickness to be assigned

* Cf. Blake, "Q. J. G. S.," vol. xxxi. p. 198; and Brodie, "Proc. Geol. Assoc.," vol. iv. p. 517.

to it. Fitton says 120 feet, Blake 240 feet. The meaning of this is that there is no good line of demarcation between this formation and the Kimeridge Clay. The thickness of the Upper Jurassics in the Isle of Purbeck is very great, being however pretty much the same as was found to obtain in the Subwealden boring, which must be regarded as being situated in that same fold of the old sea bed which received such immense accumulations during the close of the Jurassic period.

The return was made through the picturesque hollow of Renscombe to the farmhouse at Weston and thence by carriages to Worth and Swanage.

Second Day.—The members assembled at the foot of the zigzag path in the very centre of Durlston Bay, at the spot where the fault marked *f* in the section Fig. 112 strikes the coast. This is a good point for commencing. The effect of the throw is very conspicuous. As one faces the cliff the hard Cinder bed on the left, which is about the centre of the Middle Purbecks, is brought into juxtaposition with the soft lower beds of the Lower Purbecks on the right. The effect is not exactly the same as is shown in the section, since all the beds at the fault are lower on the coast than in the actual line of section. The amount of throw may be about 150 feet. The thickness of the Purbecks in Durlston Bay is variously estimated. Mr. Bristow's vertical section gives 370 feet.

The advantage of commencing at this spot consists in being able to work up the entire sequence in ascending order from here to Peverel Point, the very lowest beds alone being concealed. Professor Morris gave a sketch of the fauna and subdivisions of the Purbecks, together with a notice of the physical conditions which, in all probability, accompanied the deposit and a comparison of these beds with the Purbecks of other areas. He especially dwelt upon the change from fresh-water to marine conditions, showing that, although the change from marine through brackish to fresh water is gradual, the change from fresh-water to marine conditions was abrupt, indicating, as it were, sudden inroads of the sea. He also ventured to call in question the absolute change of species said to occur in the three subdivisions of the Purbecks. The remarkable vertebrate fauna was then alluded to and special description given of the mammalian remains discovered by Messrs. Beckles and Brodie and described by Prof. Owen and Dr. Falconer. Up to the year 1856 Mr. Beckles had collected twenty-eight individual and Mr. W. R. Brodie seven individual

specimens—thirty-five in all, and these consisted of fourteen species, mostly insectivorous marsupials, though one (*Plagiaulax*) was believed to be an herbivorous quadruped allied to the kangaroo-rat (*Hypsiprymnus*).

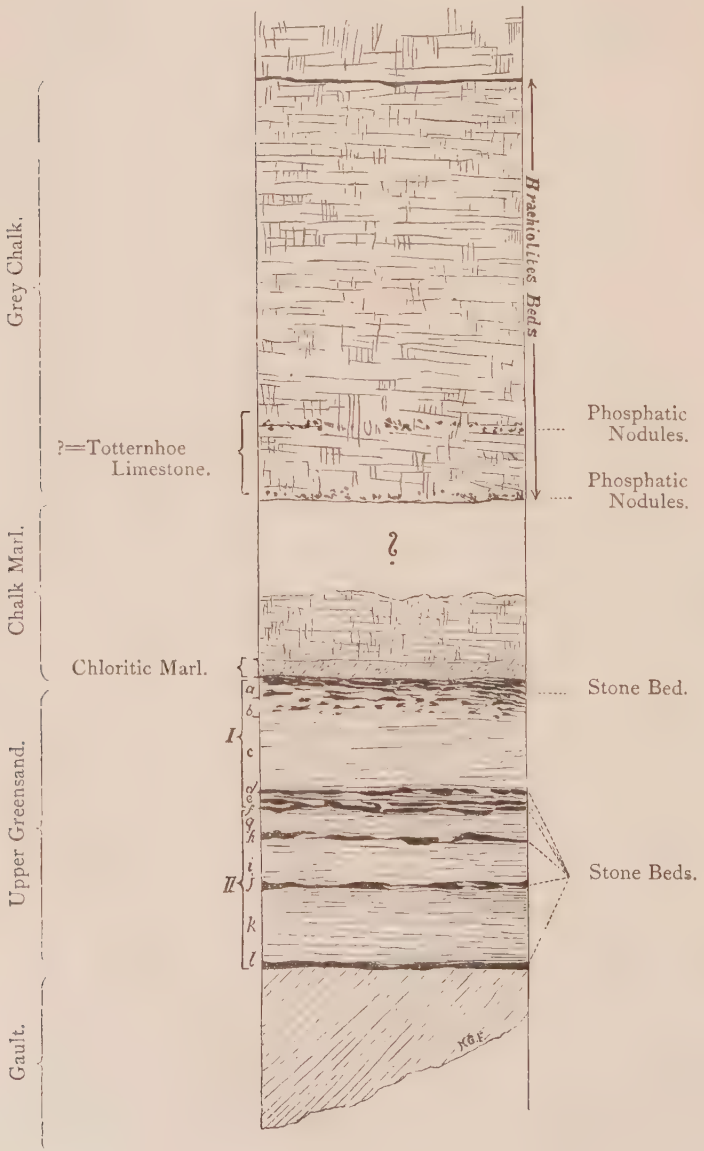
Along the beach species of *Cypris* were discovered, together with specimens of *Melania*, *Paludina*, *Planorbis*, *Cyclas*, *Cyrena*, &c., and in the more marine bands *Pecten*, *Modiola*, *Corbula*, *Ostrea*, &c. The Lower Purbecks are remarkable for immense concretionary masses of gypsum; they contain here no workable stone. At the base of the Middle Purbecks occurs a sort of marly dirt bed a few inches thick, in which the mammal bed is found. There was some difference of opinion as to which was the real bed, but this was finally settled to the satisfaction of all parties. The Middle Purbecks are, on the whole, the most interesting and valuable. They contain five beds of stone. Three of these are above the Cinder bed; two are below. The following is the order of their occurrence:—1. The Laning Vein. 2. The Free-stone Vein. 3. The Downs Vein—the Cinder, a thick bed of *Ostrea distorta* and other shells. 4. The Cap and Feather. 5. The New Vein. Remains of turtle and fish are frequently found in these beds by the workmen. The base of the Upper Purbecks is characterised by the Burr beds—not now worked—near Swanage. Above these are the *Unio* beds and in this series occurs the Crocodile bed—a blue-hearted, gritty limestone full of skin and teeth and other remains of *Goniopholis crassidens*, together with wood, fish-palates, turtle, &c. Abundance of fragments were secured. With the *Paludina* beds (Purbeck marble) of Peverel Point this most interesting ascending section terminates. There is a good deal of complex folding here, and the principal rock beds are thrown into a synclinal, which may have the effect of strengthening the Point and thus saving the town of Swanage.

In the afternoon the party walked along the shore of Swanage Bay, past the Hastings-Wealden beds, which, though said to be 1,800 feet thick, are but poorly fossiliferous. Variegated clays and sands, dipping northwards at an angle which increases as the chalk is approached, are the chief features. Bones of *Iguanodon* have rolled out of them occasionally.

The centre of interest lay in Punfield Cove, not only because of the discussion as to the so-called Punfield beds, but because the monotonous character of the strata undergoes a considerable change at this place and the beds immediately underlying and at the base of the chalk possess features of considerable interest.

FIG. 113.—GENERAL SECTION OF UPPER CRETACEOUS OF SWANAGE BAY. [Fordham.]

Scale 48 feet = 1 inch.



The beds involved in the Punfield controversy, including what Professor Judd allows to be "Upper Neocomian," are over 200 feet thick (these are all included in the upper part of *h* 1 of Mr. Bristow's section). The Gault cannot be measured; the Upper Greensand, according to Fordham, is 70 feet thick, the Chloritic Marl 4 feet, the Chalk Marl 40 feet, the grey Chalk 100 feet. The dip is for the most part about 65° towards the N.

The party being assembled in full view of the Punfield section the Directors first gave a brief history of the controversy on the Punfield beds, and, secondly, endeavoured to point out the various horizons which are mentioned in the writings of Messrs. Judd and Meÿer.

As regards the points in dispute Mr. Meÿer observes that he and Prof. Judd agree in the main as to the stratigraphy, though in a second paper he supplements his section with some important details. The sequence below the Gault is somewhat as follows in descending order:—

	ft.	in.
1. Grey Clays alternating with ferruginous sandy beds. *Exogyra sinuata*, *Panopæa neocomiensis*. "Upper Neocomian" . .	60	0
2. *The Cypridiferous beds with their bands of Limestone made up of* Cyrena, Ostrea, &c. *Not seen either by Judd or Meÿer* . .	?6	0
3. Ferruginous sands with interlaminated clays and lignite, in the middle several bands with oyster and other marine shells . .	153	0
4. "The marine band of Punfield," with a rich and novel fauna, representing, according to Meÿer, in common with the rest of the Punfield beds, three elements, *viz.*:—(1) A set of marine or brackish-water mollusca peculiar to this locality and to the coal-bearing strata of Eastern Spain. (2) About four species of brackish-water molluscs, a *Cardium*, a small *Ostrea*, and *Corbula* or *Potamomya*, and a species of *Mytilus*. (3) A group of fossils common in the Neocomian beds of Atherfield and Shanklin .	1	9

With the marine band, according to Prof. Judd, the Punfield series terminates, being succeeded in descending order by the variegated beds of the Wealden. But Mr. Meÿer has obtained

abundant indications of marine shells a long way below this and he places 100 feet of beds between the marine band and the variegated beds of the Middle Wealden. Continuing the section downwards we have, according to Meÿer—

5. Blue Clay with *Arca* and Marine Crustacean (Atherfield "lobster").
6. Band containing abundance of Lower Greensand fossils.
7. Blue Clay which may be on the horizon of the *Perna* bed at Atherfield.
8. GRIT BAND associated with *Cypris* and remains of small fish.
9. Blue cypridiferous shales and clays of the UPPER WEALDEN, for the most part masked.

The difference of opinion between Judd and Meÿer amounts to this—the former regards the beds between the admitted Upper Neocomian and the Variegated Wealden as a "fluvio-marine" series, having certain analogies with the coal-bearing beds of Utrillas, in Eastern Spain. Meÿer, on the other hand, regards the whole as a littoral facies of the Lower Greensand and he prefers to place them on the horizon of that of the Isle of Wight rather than correlate them with any portion of the underlying series as developed in that island.*

Meÿer's *grit band* was taken as a datum line and from this line upwards the investigations were carried. The Grit band dips northwards at about 65° and the overlying beds are strictly conformable. Subjoined is an account of the section cleared, which may be deemed fairly accurate as far as it goes. From above downwards :—

BASE OF THE PUNFIELD SECTION.

	ft.	in.
F. Clays with abundance of marine fossils . .	1	9
E. Ironstone nodule	0	6
D. Upper black *Cypris* Clay, with more of the tuberculated forms than in the lower beds . .	2	7
C. Banded and variegated greyish sandy clays. Unfossiliferous	4	3
B. Cypridiferous black clays with two species of *Cypris*	0	9
A. GRIT BAND; a lime-bound quartz grit with fragments of bone. Shales and clays of the UPPER WEALDEN.		
Total measured . . .	9	10

* For later views on this subject see A. Strahan, in the new edition of Bristow's "Geology of the Isle of Wight."

It is evident, therefore, that a Wealden fauna extends above the Grit bed to a higher point than supposed by Meÿer. The nodule line, E, represents the junction bed between the Wealden and Lower Greensand fauna. How far the top of this fauna lies below the original "marine band" the members had no means of judging.

These operations took up so much time that the contemplated walk across Ballard Down to Studland Bay had to be deferred to another opportunity.

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EXCURSION TO WEYMOUTH AND PORTLAND.

Easter Monday, April 14th, 1879, and Following Day.

Directors—Prof. J. F. Blake, F.G.S., and W. H. Hudleston, F.R.S.

(*Proc. Vol.* vi. *p.* 172.)

First Day.—Members assembled at Upway Station, between Dorchester and Weymouth. Here they were met by the Directors and proceeded to inspect the quarries on Ridgway Hill, principally in the Purbecks, 190 feet thick, beneath which is a considerable thickness of Portland limestone with large fossils and

many flints. The railway, as it emerges from the tunnel underneath Bincombe Down, affords in the cutting a section which has thrown much light upon the Ridgway fault. From the neighbourhood of Upway the party took the most convenient route to Osmington and reached the coast at Osmington Mill. The disturbance which further west has produced the saddle of Forest Marble may here be noted as a fault. Near the Cascade the Calc Grits at the base of the Corallian series are well exhibited. The tide being suitable the members proceeded along the scar at the foot of the cliffs and examined the very fossiliferous exposure of the Corallian *Trigonia* beds capped by an alternating series of clays and red grits and surmounted by Kimeridge Clay. Further westward they regained the summit of the cliff, walked along the footpath to Jordan Hill and thence proceeded to Weymouth.

Second Day.—The party met on the jetty, beneath the Nothe Fort. The harbour lies on Oxford Clay, and immediately to the south begins the Corallian series. An examination was made of the upper succession of Nothe Grits, Nothe Clays, Bencliff Grits, Oolites and *Trigonia* beds; to which succeed the Sandsfoot Grits and Clays, and then the Kimeridge passage beds. A sea-wall has here been built on the Kimeridge Clay, to counteract the effects of the change of currents brought about by the breakwater. The members then proceeded towards Chesilton by the shore and noted the increasing size of the pebbles of the Chesil Beach towards Portland. Proceeding eastward, beneath the Verne, they examined the section upwards from the Portland Sand. The latter is here somewhat argillaceous and contains beds of oysters. The Portland rock, with its "Roach," was seen in most of the quarries on the summit, capped by the Purbecks with their dirt beds. Returned by train to Weymouth.

The following explanation of the geology of this district was given with the programme of the excursion:—

The *Forest Marble*, constituting the upper division of the Lower Oolites, consists, within the district, of grey marls and marlstones, blue clays, and beds of stone, composed of comminuted shells, covered by the *Cornbrash*, a loose rubbly limestone alternating with thin beds of clay. The *Oxford Clay* is estimated to be 300 feet thick. In the backwater of Weymouth it has yielded many characteristic ammonites and large septaria which used to be cut into slabs. The *Corallian* series, formerly known as the Coralline or Oxford Oolite and Calcareous Grit, and more recently as Coral

Rag, has a thickness of about 230 feet on the south side of the anticlinal and of about 180 feet on the north side. It consists of a central core of impure limestones, sometimes oolitic, and in places extremely fossiliferous, bounded above and below by calcareous grits and clays in several alternations. Corals are rare, but more numerous towards the top of the upper grits. The *Kimeridge Clay* is probably nearly 1,000 feet thick; it is more bituminous than the Oxford Clay. The clay bottom of the anchorage at Portland is in this formation. The *Portland Sand* is eighty feet thick, and, though usually glauconitic, it is scarcely, if at all, so in this area. The *Portland Stone* has been estimated at seventy-five feet on the island, the lower portions are very siliceous. The *Purbeck* series, being for the most part of brackish-water origin, is very variable; only a few feet of the lower division now remain on the Island of Portland. The *Hastings Sands*, though not shown on the Section, occur in the Ridgway cutting, and are marked on the Survey Map to the east of Osmington. The *Upper Greensand* is stated to be about 100 feet thick, and consists, towards the base, of dark argillaceous greensand, succeeded by variegated sands, alternating with irregular calcareous concretions and thick beds of chert, and capped by a chalky, and in places fossiliferous glauconite, known as the *Chloritic Marl*, upon which rests the *Chalk*, which itself is capped by outliers of the *Lower Tertiaries* of the Hampshire basin. The contents and mode of occurrence of some of the *Quaternary beds* have afforded material for investigations relative to the age of upheaval and sculpture of the anticlinal.

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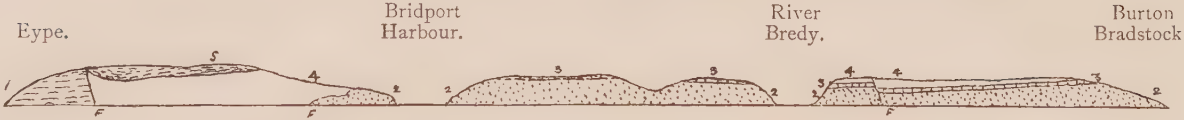
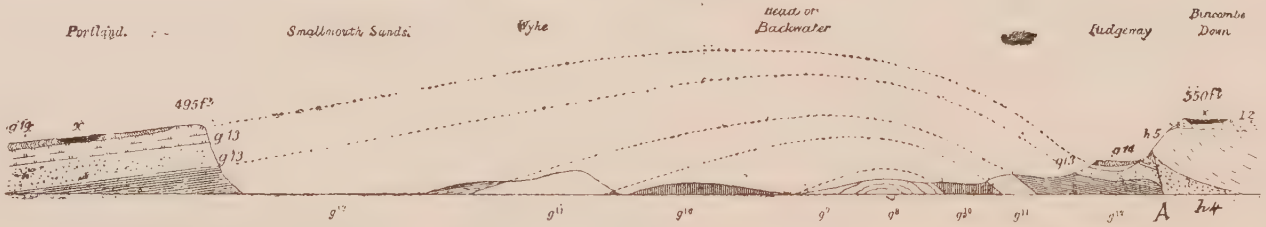
FIG. 114.—SECTION OF CLIFFS NEAR BRIDPORT HARBOUR.

Horizontal scale—2 inches to 1 mile. Vertical exaggerated. Highest part of cliffs about 190 feet.



5. Forest Marble. 4. Fuller's earth. 3, 2. Inferior Oolite. 1. Middle Lias. *F*. Faults.

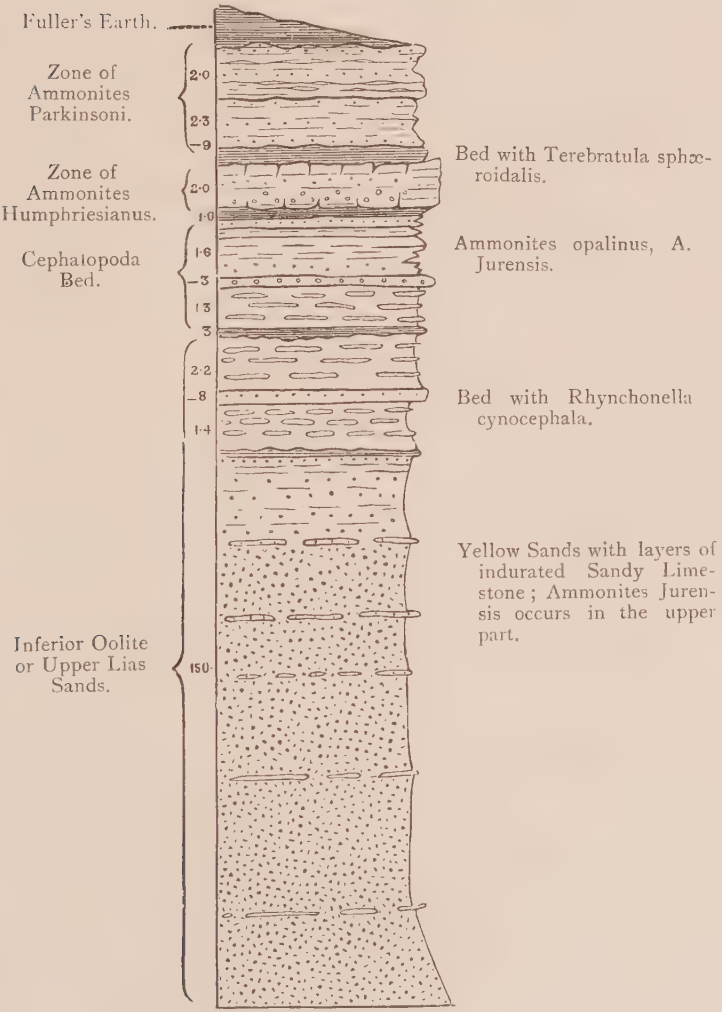
FIG. 115.—THE WEYMOUTH ANTICLINAL.



g^8 and g^9. Forest Marble and Cornbrash. g^{10}. Oxford Clay. g^{11}. Corallian. g^{12}. Kimeridge Clay. g^{13}. Portland Sand. g^{14}. Purbeck. h^4. "Upper Greensand." h^5. Chalk. i^2. Lower Tertiaries. *x*. Quaternary Deposits. A. Ridgway Fault.

FIG. 116.—VERTICAL SECTION OF CLIFFS AT BURTON BRADSTOCK, NEAR BRIDPORT HARBOUR. [Damon.]

By R. ETHERIDGE, F.R.S.



Prestwich, Quaternary Period in the Isle of Portland and round Weymouth, Quart. Journ. Geol. Soc., vol. xxxi. p. 29. 1875.

Blake, Kimeridge Clay of England, Q. J. G. S., vol. xxxi. p. 196.

Blake and Hudleston, The Corallian Rocks of England, Q. J. G. S., vol. xxxiii. p. 260. 1877.

[An excursion to *Sherborne* and *Bridport* took place on May 25th and 26th, 1885, W. H. Hudleston, F.R.S., and H. B. Woodward being Directors. See Report, Proc. vol. ix. No. 4, pp. 187-199. And at Easter, 1889, an excursion took place to *Lyme Regis* and *Weymouth* and *Portland*, Messrs. Hudleston and Woodward being again Directors. The party reached *Lyme Regis* on the evening of Thursday, April 18th, and started for *Weymouth* early on the morning of Monday, April 22nd. For report see the November number of the Proceedings, 1889 (vol. xi. pp. 26-57.)]

WESTERN COUNTIES.

SOMERSET AND GLOUCESTERSHIRE.

EXCURSION TO THE YEOVIL DISTRICT.—May 29th, 30th, 31st, and June 1st, 1871.

Directors—Professor Buckman, F.G.S., and J. Logan Lobley, F.G.S.

(*Report by* J. L. Lobley.)

(*Proc. Vol.* ii. *p.* 247.)

The Yeovil Junction section of the beds of yellow micaceous sand, which are considered by some geologists to be a portion of the Upper Lias and by others to belong to the Inferior Oolite, was seen immediately the party alighted from the train. The Sands are here exposed to a depth of sixty or seventy feet, and are capped at a few yards from the side of the railway cutting by beds of undoubted Inferior Oolite, containing the usual species of this formation in abundance, including *Rhynchonella spinosa*, *Terebratula Phillipsii*, *Lima proboscidea*, &c.

Leaving the section at Yeovil Junction the members proceeded by a country road to the village of Closworth, passing over the Fuller's Earth and the Cornbrash, and reaching the Forest Marble on arriving at the village. At the rectory luncheon was provided by the rector, the Rev. E. Bower, M.A. The inspection of the large collection of Mesozoic fossils, which Mr. Bower has during fifty years brought together, occupied several hours. It is worthy of remark that the Rev. Mr. Bower has shown his appreciation of the Forest Marble of his parish by using it as an ornamental stone in the restoration of Closworth Church. After leaving Closworth the road to the town of Yeovil was taken, and several sections of the Fuller's Earth and the yellow or, more correctly, buff-coloured Sands of the district were observed.

The members dined together and subsequently inspected the collection of the fossils of the neighbourhood of Yeovil in the

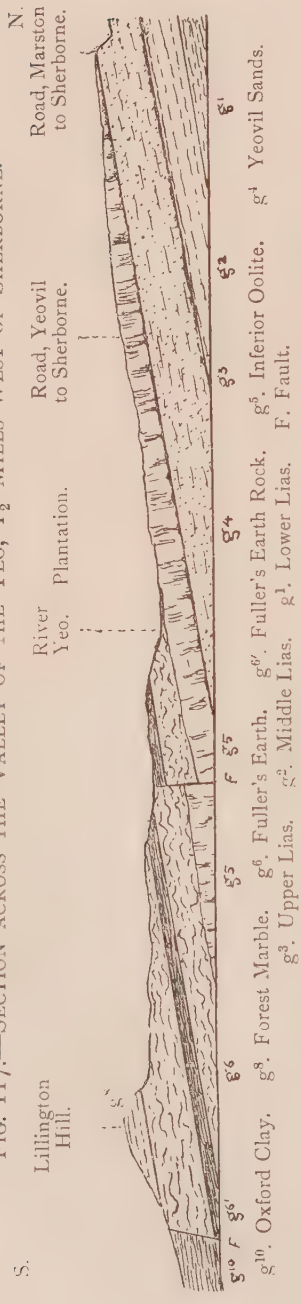


FIG. 117.—SECTION ACROSS THE VALLEY OF THE YEO, $1\frac{1}{2}$ MILES WEST OF SHERBORNE.

possession of Mr. T. C. Maggs of that town. This collection, though not as yet large, contains very fine specimens.

Early on the second day the fine escarpment of Babylon Hill, which bounds at this place the valley of the Yeo, was ascended under the guidance of Professor Buckman, by a road cut through the Sands. This section of the Sands is an extremely fine one, exposing the beds to a depth of 150 feet. Bands of concretionary limestone, sometimes continuous for long distances, but more frequently intermittent, project from the surface of the cliff. The fertile and beautiful valley of the Yeo is well seen from the escarpment and the course of the river towards the sea can be traced for many miles. Professor Buckman here pointed out the physiography of the country south of the Mendips and afterwards led the way to a section of fossiliferous Inferior Oolite overlying the Sands. The party then proceeded along the road to Sherborne, as far as the celebrated Half-way House quarries. The Fossil bed here exposed was examined and many fossils were obtained.

Entering the county of Dorset, and continuing along the road to Sherborne, that town was reached after a walk of about two miles over the Inferior Oolite. Near the town are extensive quarries, and these afford fine exposures of the Inferior Oolite, which is

at this place a light-coloured, compact freestone, used for building purposes. Fossils are abundant, especially Cephalopoda and Brachiopoda. *Ammonites Humphriesianus* and *A. Blagdeni*, with Nautili and Belemnites of large size and in a fine state of preservation, are numerous, and Terebratulæ are very common. Some time was accordingly spent in collecting, after which the members proceeded by rail to Bradford Abbas. Here a fine opportunity was afforded for the study of the Fossil bed. The Professor conducted his visitors to a small quarry on his farm, where a quarryman with a pick exhumed, in a few minutes, great numbers of fine Ammonites.

Professor Buckman entertained the party at dinner and afterwards expounded his views on the geology of the district, with especial reference to the position of the Sands and the "Cephalopoda bed." *

The concretionary masses of the Sands, it was stated, contained fossils essentially Oolitic and not Liassic, and the evidence appeared to Professor Buckman overwhelmingly in favour of these sands being of post-Liassic age and belonging properly to the Inferior Oolite series. It remained, however, to be shown to what portion of the Inferior Oolite they belonged, whether to the lower, the middle, or the upper division; whether they were the equivalent of the Sands of Gloucestershire, as seen at Nailsworth and Frocester Hill, of the "Pea Grit" and "Fimbria beds," or of the "Gryphite Grit" and uppermost beds of the Gloucestershire Oolites. In this place it can only be said that Charles Moore correlated the Sands in the neighbourhood of Yeovil with those at the base of the Inferior Oolite in Gloucestershire, while Buckman considered them to be equivalents of the middle and of a portion of the upper division of the Inferior Oolites of Gloucestershire, and the "Cephalopoda bed" of this district to be at the top instead of at the base of the formation, as had been hitherto supposed.

On the following day, after an inspection of a collection of Jurassic fossils belonging to Mr. Henry Monk, of Yeovil, the far-famed quarries of Ham Hill were visited, and the great bed of Inferior Oolite freestone, which has supplied material for the churches and other buildings of the district for centuries, was

* It should be mentioned that the Fossil beds in this neighbourhood are all, to a certain extent, Cephalopoda beds, but they occur on different horizons, and are above the well-known "Cephalopoda bed" of the Cotteswold Hills.
H. B. W.

carefully examined. This remarkable bed is chiefly composed of comminuted shells cemented together with carbonate of lime and peroxide of iron; but, strange to say, not a fragment of a shell has been obtained from this vast deposit of sufficient size for the species to be determined. [Since then Mr. H. B. Woodward has obtained specimens of *Rhynchonella cynocephala*, a fossil characteristic of the Gloucestershire Cephalopoda bed. (Proc. Bath Nat. Hist. Club, vol. vi. p. 184.)] Ham Hill rises steeply from the surrounding country on three sides, and the commanding character of the eminence appears to have been early recognised, since the remains of a very ancient camp, probably Roman, are to be found on the summit. Leaving the hill behind the party traversed the rich vale to the west, and in a short time arrived at the little village of South Petherton, made well known to geologists by Charles Moore, who has obtained from this locality a rich and interesting fauna. South Petherton stands on the Lias which is here quarried for lime-burning, and the sections thus produced show the Middle Lias or Marlstone, with a thin capping of Upper Lias. The Marlstone is very fossiliferous, yielding Cephalopoda, especially Belemnites, most abundantly. Brachiopoda are also numerous. *Spiriferina rostrata*, *Rhynchonella acuta*, and *R. tetrahedra* being perhaps the most common. In the Upper Lias Moore found several species of *Leptæna*, a genus previously considered to be exclusively Palæozoic.

On the return to Yeovil several sections of the Middle Lias were seen. The Marlstone on which Yeovil stands, and which underlies the yellow Sands forming the hills around the town, is quarried for inferior building stone and road-metal. It is very hard and tough, and contains many fossils, amongst which may be specially noted, as being conspicuous on account of both size and abundance, *Pinna Hartmannii* and *Pecten æquivalvis*.

The fourth day was devoted to an examination of the fine coast section extending eastwards from Seaton in Devonshire. The Keuper Marls are here seen forming richly coloured, picturesque cliffs of a hundred feet in height, which stretch along the shore from the mouth of the Axe for upwards of a mile, when Rhætic and Liassic strata begin to appear, and afterwards form, with a capping of Upper Greensand, the cliff, until the famous landslip is reached. Enormous blocks of chert, precipitated from the Upper Greensand at the top of the cliffs, lie at their base, and abounding, as they do, with sponge spiculæ, are objects of great interest. The party returned to London in the evening.

EXCURSION TO BATH.—May 20th and 21st, 1872.

Directors—Charles Moore, F.G.S., and The Rev. H. H. Winwood, F.G.S.

(*Report by* The Rev. H. H. Winwood.)

(*Proc. Vol.* iii. *p.* 89.)

The members were received at the Bath Literary and Scientific Institution and were conducted through the Museum containing the valuable and interesting Palæontological Collection, which is almost solely the result of one long life of patient research—the contribution of Mr. Charles Moore to Geological Science.

The party then proceeded, under the guidance of the Rev. Mr. Winwood, to visit some of the sections in the immediate neighbourhood. The first halt took place at the Newbridge Hill cutting, on the Bath and Mangotsfield Railway, permission having been kindly granted by the authorities for this special visit. Mr. Winwood, who has read a paper before the Bath Field Club on this section (Proc. Bath Field Club, vol. ii., 1871, p. 204), gave a short sketch of the boundaries of the Bristol and Somersetshire coal basin, at the eastern edge of which the members were then standing, made a passing allusion to the remarkable thinning out of the Secondary beds to the north of the Mendip range, evidence of which he hoped to show the members in their morrow's walk, and then gave a general idea of the section before them. Extending in a N.W. and S.E. direction the members saw exposed a series of beds from a thin representative of the bone bed, a little below the present rails, through the superincumbent shales, with intervening hard, light blue, or grey marly bands onwards through the Cotham Marble or Landscape stone at the base of the White Lias, and upwards through this latter formation and thin representatives of *Ostrea* and *Ammonites angulatus* beds to the dark blue clays of the *Lima*, or *A. Bucklandi* series of the Lower Lias.

All the beds from the New Red Marl, faulted up at the farthest end of the cutting, upwards to the topmost bed of the White Lias, called the "Sun bed" by William Smith, were now considered to be the English representatives of the Rhætic beds on the Continent. Though the bone beds and *Avicula contorta* shales were much better represented in the Garden Cliff and Aust sections, yet probably nowhere else was the White Lias so admirably exposed, graduating from the rubbly and fossiliferous beds above the

"Landscape stone" up to the thick and compact "Sun bed," so persistent in the Somersetshire sections. Attention was called to the pretty series of steplike faults which finally caused the White Lias to dip rapidly beneath the railway and disappear altogether at the S.E. end of the cutting. After these preliminary remarks the members made a closer inspection and were enabled to satisfy themselves of the position of the bone bed, with its characteristic *Pecten valoniensis*, and that the true Rhætic fossils were present. Specimens of the "Sun bed" were carried away for analysis, and the distinct lithological change between this bed and the thin yellowish-brown arenaceous band, containing *Ostrea liassica* (at the base of the Lower Lias), which persistently overlies it, was an evident and marked feature.

Dr. Wright, of Cheltenham, contributed information respecting the general question of the position of the Rhætic series. The party then made for the Twerton quarries, passing on their way a small exposure of mammalian drift, consisting principally of pebbles from the rocks of the neighbourhood, Oolite, Lias, Mountain Limestone, flint, chert, &c. Arrived at the quarries, where a fine exposure of the Lima beds of the Lower Lias was seen, those unacquainted with the district were surprised to find a coal shaft sunk through and coal won at a depth of 118 fathoms beneath the Lias. Several characteristic fossils were obtained and the members returned to Bath.

On the following day an early start was made and the Great Oolite quarries on Hampton Down were first visited. A few words on the workable "freestone" beds which intervene between the upper and lower "Rags" and are here about twenty-five feet in thickness and the members passed along the edge of the down overhanging the beautiful Valley of Warley and reached a hollow formed by the falling in of the roof of the numerous galleries which run into the hill. Here Mr. Winwood pointed out the brown, raggy, coralline bed, about nine feet thick, whence Moore had obtained so many of the sponges, polyzoa, and corals now in his collection, and several specimens were collected from the weathered edges, together with *Terebratula cardium*, &c.

A walk across Claverton Down took the party to the Dundas Aqueduct. The members were brought here to see an illustration of the thinning out of the Secondary beds previously alluded to. They saw before them one of the few sections where the Upper Lias had been found in this neighbourhood. They were then standing, according to the section given by Moore, on the blue

...ceous marl, twenty feet in thickness. Just above this came a band of Marlstone, one foot thick; blue clay, three feet; Upper Lias, one bed, one foot thick; and grey clay, two feet; succeeded by the sands of the Inferior Oolite, twenty feet; thus the Middle and Upper Lias, which are of great thickness in the north of England, are here reduced to seven feet. *Ammonites bifrons* (*Walcoti*) and *A. serpentinus* (?) were obtained from some of the blocks lying about and one or two *Lingula Beani* from the brownish Marlstone. It must be confessed, however, that, owing to the section being so covered with luxuriant growth, a good deal was left to the imagination to fill up, aided by the statements of those who have worked it out before. A traverse through a keeper-guarded wood and along the canal bank, crowded with recent Mollusca, the result of bottom dredgings for mud, and the last section was reached—the section whence Lonsdale obtained many of his Inferior Oolite fossils. A small exposure of the sands was seen at one end rising immediately from the banks of the canal, the bed of which is in Lias clay, and succeeding these sands came the Inferior Oolite, with the Fuller's Earth clays on the top, but not visible. Several fossiliferous bands were seen in the beds. Time did not permit of a visit to Freshford gravels, whence the cranium of *Ovibos moschatus* has been obtained, and accordingly the members returned to Limpley Stoke and took the train to Bath.

EXCURSION TO BATH.

Whit-Monday, June 2nd, 1879, and Following Day.

Director—Charles Moore, F.G.S.

(*Report by* The Director.)

(*Proc. Vol.* vi. *p.* 196.)

The members were met at the railway station by their Director and accompanied him to the Free Museum. On arrival there Mr. Moore informed his audience that the fine room in which his collection was located had been placed at his disposal for its reception twenty-seven years ago by the Committee of the Literary and Scientific Institution, and that during that period it had been entirely under his own supervision, unaided by any public or private funds, except that when, in consequence of the growth of the collection, no more space was available, a generous contribution from Mr. Handel Cossham, F.G.S., enabled him to place a

gallery round the Museum, considerably extending its table and wall space. In speaking of its contents Mr. Moore remarked that his visitors would observe the fine series of reptilian remains arranged on the walls, and that, including others that would be found in the table-cases, there were not less than forty-three more or less perfect examples in the collection, in the pleasurable development of all of which his hammer and chisel had alone been employed.

It would be seen that the collection was a general one and stratigraphically arranged, but it was chiefly illustrative of the geology of Somersetshire and the south-west of England.

Notwithstanding the great thickness of the Keuper Beds there are but few horizons that yield organic remains and these belong chiefly to scattered Vertebrata. With this exception he had only found plants and *Estheria*, a single cast of a *Modiola*, and a derived encrinital stem, which showed how inimical must have been the physical conditions of this period to the life of the Testacea.

Respecting Keuper Vertebrata he had been more fortunate. In an excavation in the variegated marls, for the foundations of a house at Ruishton, he observed a thin layer of sandy conglomerate, and the result of an investment in a load of it which was sent to Bath was the series of remains in the case before them. Amongst these were teeth of *Thecodontosaurus* and *Palæosaurus*, *Batrachia*, *Sphenonchus* and *Diplodus*, with their curved fangs, and allied to them a form with three much recurved teeth, which had not before been noticed, and which might be named *Triplodus*. It is probable that the Budleigh Salterton and Sidmouth red marls, which also contain vertebrate remains, occupy a lower position in the series, and that those of Ruishton are on the horizon of the Pendock and Warwickshire Keuper. From the sandy and unconsolidated character of the Ruishton bed the fossils are exceedingly brittle.

In the table-case following the above is the wonderful series of remains from the Holwell Rhætic drifts, which were found in friable marly deposits caught up in veins of Carboniferous Limestone. Samples of the matrix were placed in the case. There were in the case thousands of fragmentary and worn bones, and, including others, and mammalian, reptilian and fish teeth, hundreds of thousands more perfect. As many of these were of small size Mr. Moore exhibited enlarged drawings, with about two hundred figures of detached bones and teeth represented in the

series. The teeth of *Microlestes Moorei*, Owen, and *M. antiquus*, Plien., were inspected, and illustrated by a recent head of the little kangaroo, *Bettongia*, from Australia. Mr. Moore pointed out three toe-bones of a large dinosaurian reptile, allied to *Scelidosaurus*, which were found in the regularly stratified Rhætic marls, and teeth of *Thecodontosaurus* and *Palæosaurus*, genera which had been found many years before in conglomerate on Durdham Down, also associated with Carboniferous Limestone. It was specially pointed out that, although the same *genera* of Vertebrata were found in the Keuper and Rhætic beds of this country, the *species*, with few exceptions, were quite distinct, and it was still more doubtful if any from the latter beds passed into the "White Lias," or into the "Lower Lias" above. In his experience of forty years, no reptilian bone had ever been found in the White Lias, and though several small fish had been met with in the "landscape-stone" of Bristol, he had never found more than one solitary fish bone, though such countless numbers must have existed to have formed the bone bed but a few feet below. Changes in the physical condition of the deposits probably accounted for their absence in the White Lias. Following the Vertebrata the typical Mollusca of the Rhætic series, figured and described by Mr. Moore, were noticed, and the paucity of their remains in the White Lias also referred to.

The organic remains from the Lower Lias next followed, amongst which were many new species, but he should only ask their attention to the new Corals and to the Reptilia. Only six or seven species of corals were known a few years since in the whole of the Liassic series, until he was fortunate enough to go into a small Carboniferous Limestone quarry at Brocastle, South Wales. On the top of the limestone he recognized a thin band of Liassic conglomerate, which, in addition to other remains of interest, eventually yielded him thirty-five species, which had been described by Duncan (Pal. Soc., 1866-1872). Amongst the Reptilia he need scarcely direct their attention to the gigantic head of *Ichthyosaurus platyodon*, probably the finest known. The head alone weighs twelve cwt. Over this head there is a small *Ichthyosaurus communis*, the whole of whose stomach is coloured by a black pigment. The fact was that the *Ichthyosauri* fed upon contemporaneous cuttlefishes and this black matter formed the contents of their ink-bags. He could trace it in nearly every specimen.

Passing the several horizons of the Middle Lias he would

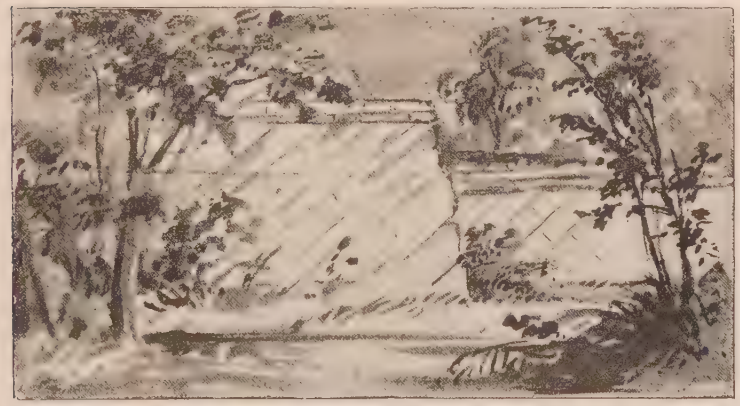
introduce them to the wonderful contents of the Upper Lias saurian and fish bed, which, though averaging less than a foot in thickness, had yielded him material sufficient to fill eleven compartments of his table-cases. The Reptilian and other larger remains are found in elongated disjointed septaria, just covering up, and still assuming the shape of the enclosed organisms. No pressure appears to have been subsequently applied to them, as they are still uncompressed, and even the stomachs of some of the Reptilia remain unconsolidated. Two species of *Pelagosauri* (*Teleosaurus*) occur, the *P. Moorei*, Desl., and the *P. typhus*. In a beautiful specimen of the former species, only thirteen inches long, a *Leptolepis constrictus* lies undigested in its stomach, and the rugose skin of the *Ichthyosauri* fringes the line of their skeletons. Passing on to the case containing the cuttlefishes it was pointed out that in every instance the ink-bag was present and still retained the dry remains of its once inky fluid. The fine series of fishes belonging chiefly to species of *Pachycormus* and *Lepidotus* next came under review, as well as *Ammonites* with their *Aptychi*. The bed contained Crustacea and many insects. The latter were in the hands of Mr. Goss, who, having given valuable contributions to the "Proceedings of the Geologists' Association" on this family, had promised one on his collection. Time only permitted slight reference to the many typical Brachiopoda in the Museum and to the Post-Pliocene remains from the gravel of the Bath basin and the adjoining valleys.

The members proceeded by railway to Vallis and Holwell.

In the Bath area occupied by the Roman city there has been an accretion of ten or twelve feet of material above its foundations, and under this follow mammal-drift gravels and alluvium, all of which rest on the lower members of the Lower Lias. In passing from the latter formation up the southern escarpment to the table-land of the Great Oolite on Combe Down, at an elevation of 600 feet, the edges of the Middle and Upper Lias, Inferior Oolite, Fuller's Earth, and Great Oolite, have been crossed, though no sections are visible, except in the Great Oolite on the down. A fault passing through the Bath Valley has placed these beds about 200 feet lower than on the northern side of the city. In less than a mile from Combe Down the narrow Midford Valley, through which the railway to Radstock passes, is crossed, and the above beds again repeated on either side. In this valley are several sections to which the term Midford Sands has been applied, but they are very insignificant as compared with their greater thick-

ness in the Yeovil and West Somerset districts. Looking down from the table-land, the position of the Radstock Coal basin was seen, and beyond it the uplifted range of the Old Red Sandstone, and the Carboniferous Limestone of the Mendips.

FIG. 118.—SECTION IN VALLIS, SHOWING INFERIOR OOLITE RESTING UNCONFORMABLY ON CARBONIFEROUS LIMESTONE.



On arrival at the Hapsford Mills end of the Vallis ravine Mr. Moore gave a descriptive notice of each of the sections and the peculiar varieties the beds presented above the Carboniferous Limestone for which they were formerly worked. At the base were conglomerates representing the ancient coast-line of the Rhætic seas, containing scattered fish remains and Reptilia, and mixed up with them patches of clays containing *Avicula contorta* and limestones, with occasional insects, and the little brackish-water crustacean *Estheria minuta*. Above these were traces of the Lower Lias, and then, to the surface, six to eight feet of Inferior Oolite. Several secondary veins with organisms passing down through the Carboniferous Limestone attracted attention.

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[Numerous local Papers in the Proc. Bath Nat. Hist. Soc.]

EXCURSION TO BRISTOL, AUST CLIFF, AND THE MENDIPS.

MONDAY, AUGUST 16TH, 1880, AND FIVE FOLLOWING DAYS.

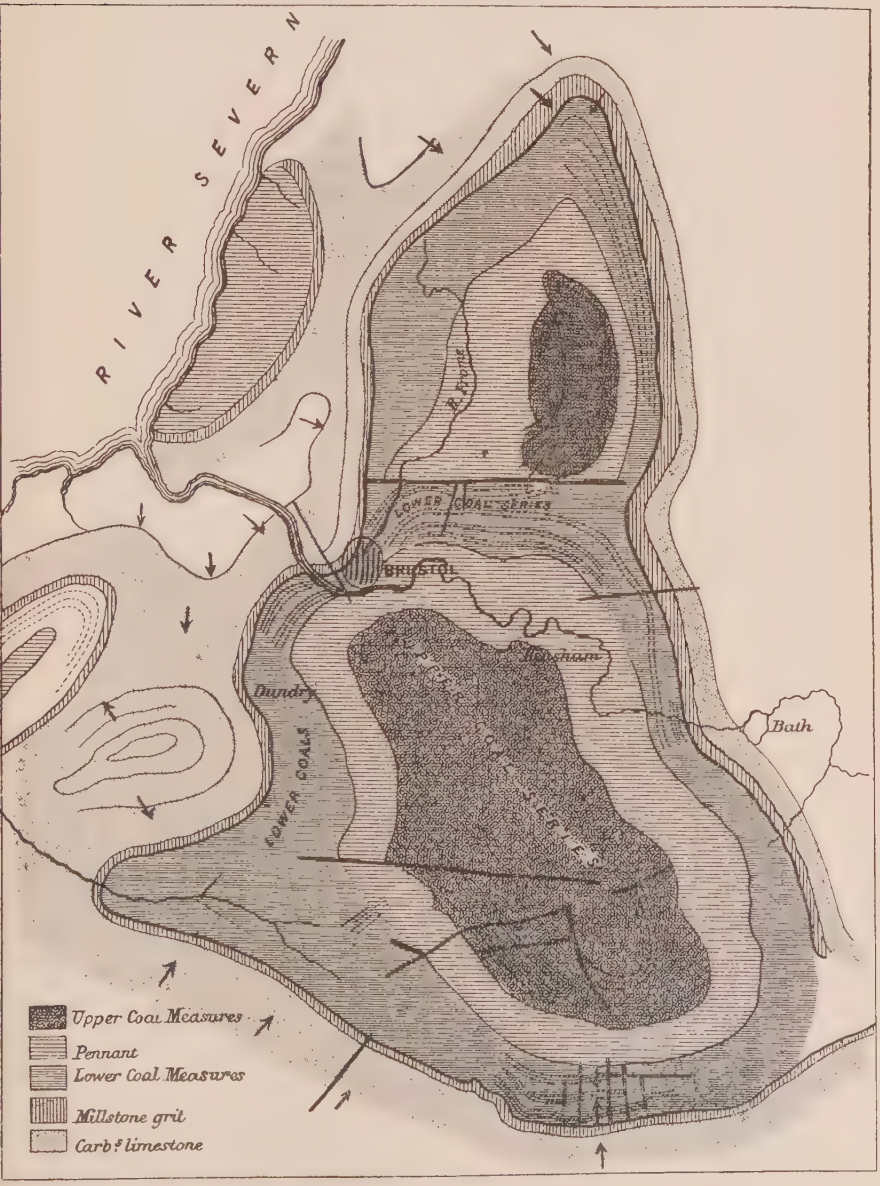
Directors—Prof. W. J. SOLLAS, F.R.S., Rev. H. H. WINWOOD, F.G.S., Rev. G. F. WHIDBORNE, F.G.S., and A. C. PASS.

(*Report by* W. J. SOLLAS.)

(*Proc. Vol.* vi. *p.* 396.)

THE members of the Association on reaching Bristol were met by the Directors and S. H. Swayne, then secretary of the Bristol Museum. On assembling outside the station they proceeded through the town to Brandon Hill, staying a few minutes on the way to observe the fine Norman gateway near the cathedral. At the foot of Brandon Hill, on the west side of Woodwell Lane (Jacob's Well), a large quarry, then being worked, afforded a good

FIG. 119.—SOMERSETSHIRE COAL FIELD, AFTER THE POST-CARBONIFEROUS DENUDATION.



exposure of the Millstone Grit and the Triassic (Dolomitic) conglomerate unconformably overlying it. The conglomerate was found to consist of fragments similar in lithological character to the grit below, affording an instructive instance of the general rule that the Triassic breccia corresponds in character to the rocks it covers, and from which it has been derived. Crossing Woodwell Lane the Trias breccia was again seen, and the walk continued from the old river fort up the hill, along the ancient line of fortification, to the summit, whence an extensive view was obtained of the surrounding country. On the north and east a thick growth of tall chimneys indicated the northern part of the coal basin; on the south-west Ashton Hill, marked by a conspicuous clump of trees, prolonged the line of the Millstone Grit on which we stood; on the south, Dundry Hill, the remarkable outlier of Inferior Oolite was seen, and on the north to north-west the buildings of Clifton scattered over Millstone Grit and Trias. From Brandon Hill the walk continued to the Museum, and here a short exposition was given by Prof. Sollas of the fossils and minerals which occurred in the formations to be visited during the week; the fish remains from Portishead, Miller's collection of crinoids, the series of Carboniferous Corals, Agassiz' types of fishes, Austin's fossils from the Millstone Grit, the Higgins collection from Aust Cliff, and the fauna of the Liassic zones were particularly pointed out.

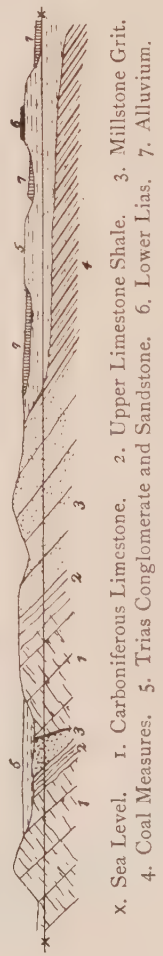


Fig. 120.—Section across Bristol from Clifton to Totterdown (3 Miles). N. 60° W.

x. Sea Level. 1. Carboniferous Limestone. 2. Upper Limestone Shale. 3. Millstone Grit. 4. Coal Measures. 5. Trias Conglomerate and Sandstone. 6. Lower Lias. 7. Alluvium.

The members then proceeded to the Observatory Hill

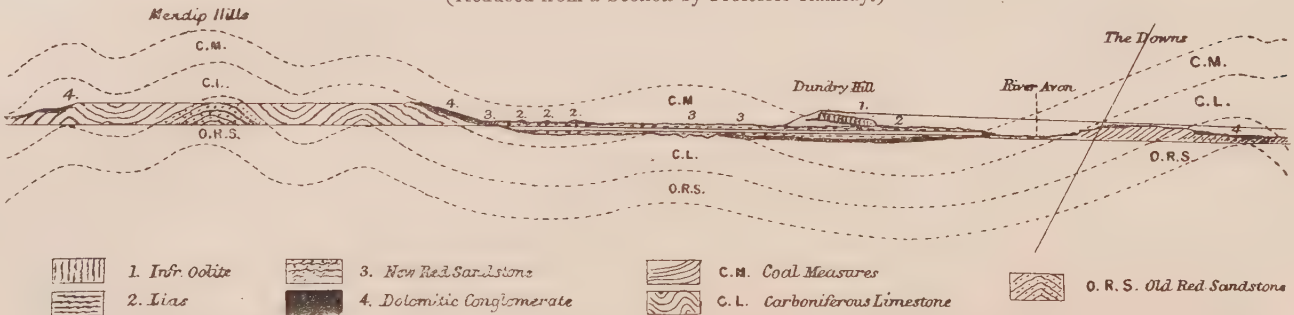
on Clifton Down, whence they looked down on the Avon gorge, bounded by the Clifton and Durdham Downs on the one side, on the other by the Leigh Woods, and spanned across by the adjacent suspension bridge. Away on the south stretched the Somersetshire part of the coal-field, the limestone of the downs plunging out of sight conformably beneath it, to reappear as it rises on the south in the faintly visible range of the Mendips (sixteen miles to the south and over 1,000 feet high). Much nearer, about four or five miles south, Dundry Hill stood clearly out to view, an outlier of Inferior Oolite in nearly horizontal beds, standing on wide foundations of Lias and still more extensive Trias, under which the Coal measures of the area are nearly altogether buried out of sight. With this hill before us, 500 feet higher than the high ground on which we stood, we were led to restore in fancy the wide-spreading sheets of Mesozoic deposits which had at one time continued the broken edges of the Dundry strata across the surrounding country and over the downs far above our heads, to end in some unknown boundary on the west. Then, dismissing from our minds the strata we had recalled for a moment into existence, and looking upon the paltry remnant preserved as Dundry Hill, we were able to gain some slight idea of the colossal magnitude of the mass which had been swept off the land and spread abroad over the bottom of the sea by subsequent denuding action.

The lowest beds of the Mesozoic are known, as was pointed out, to still extend over the downs, and, close to the place on which we stood, we were able to examine a dyke of Trias, now standing like an artificial wall at the edge of the cliff, but originally an infilling of breccia in an open joint of Carboniferous Limestone at the bottom of the Triassic sea. Mr. Pass explained that the quarrymen had removed the limestone bounding the fissure and had left the dyke itself behind on account of its greater hardness and impurity. Several other small infillings were observed, and one in particular, which had been cut through in making a new path to the cliff; this was of considerable interest, since Rhætic fish-teeth had been extracted from it. Some of these teeth were exhibited to the Association by one of the toll-takers of the bridge, who had obtained them himself and mounted them by the side of similar ones from Aust, to show their specific identity.

We then descended by the zig-zag to the river side, and walking below the cliffs from the point below Windsor Terrace to the New

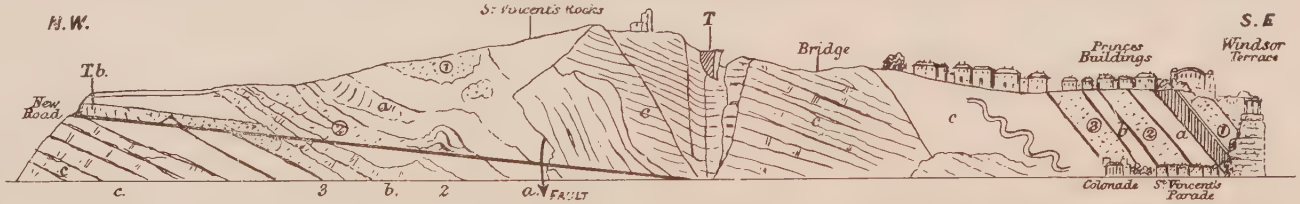
FIG. 121.—SECTION ACROSS THE MENDIP HILLS TO A POINT EAST OF THE CLIFTON DOWNS. (19 MILES.)

(Reduced from a Section by Professor Ramsay.)



The dotted lines above the Section represent that part of the strata which was removed by the post-Carboniferous Denudation. Those below, the extension of the strata beneath the ground. The straight line drawn from Dundry over the Downs represents the former extension of the Inferior Oolite in that direction.

FIG. 122.—SECTION ALONG THE RIGHT BANK OF THE RIVER AVON, SHOWING THE STRUCTURE OF CLIFTON DOWNS.



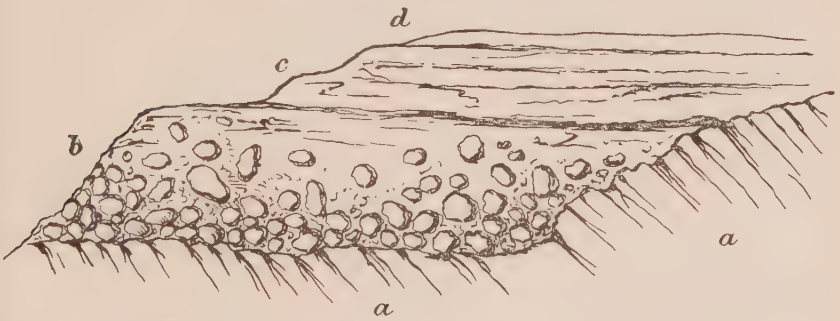
1. Millstone Grit. 2. Middle Grit. 3. Lower Grit. *a.* Upper Limestone. *b.* Middle Limestone. *c.* Great Limestone. *T.* Trias Dyke. *T.b.* Trias Conglomerate.

Road, examined the coral beds, the great fault, and made out the section here shown.

East of the section the Coal measures succeed the Millstone Grit, and are covered by New Red deposits.

Continuing along the New Road the classic section of a Trias beach, figured by De la Beche, was reached and examined (Fig. 123). The boulders, some of great size, all more or less rounded at the edges, were found to consist of Carboniferous Limestone and Millstone Grit, which are both *in situ* closely adjacent.

FIG. 124.—SECTION NORTH OF OBSERVATORY HILL, BRISTOL.



a a. Bed of Carboniferous Limestone at base of Lower Grit, brought down by a fault.

b. Boulders and Pebbles of Carboniferous Limestone, cemented by a ferruginous and calcareous matter.

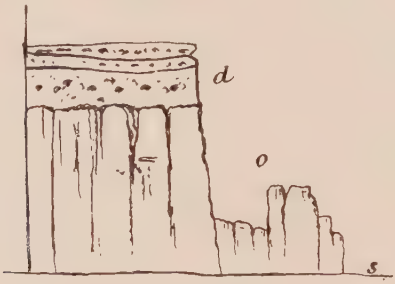
c. Conglomerate or breccia, containing more of the calcareous component.

d. Calcareous component still more in excess.

TUESDAY.—Portishead and Clevedon. The members left for Portishead, and on reaching there were joined by the Rev. B. Blenkiron, the first discoverer of fish remains in the Old Red Sandstone of Portishead. They visited the quarry near the station, where some time was spent in examining the Old Red Sandstone, Dr. Hinde finding a few imperfect fish remains. The Trias was seen resting upon it unconformably. Mr. Blenkiron then led the way to the old landing-stage, where the section figured by De la Beche, showing Trias breccia resting on the edges of vertical Old Red Sandstone beds, was observed. (Fig. 124.)

We then walked through the wood to Portishead Point and

FIG. 124.—CLIFF SECTION BETWEEN PORTISHEAD AND CLEVEDON.



d. Dolomitic Conglomerate. *o.* Old Red Sandstone. *s.* Shore.

Fort, and over the beach of Woodhill Bay, crossing numerous small anticlinal and synclinal folds of Old Red Sandstone, exposed in plan and section along the shore. We then turned inland and visited the quarry overlooking the bay; the Old Red was again seen here and a solitary fish scale obtained from one of its beds; continuing inland to the east, it was predicted, from the dip of the beds in the quarry, that we should soon reach the Carboniferous Limestone, and fragments of the Polyzoa beds were, in accordance with the prediction, found scattered over a field. We then returned to the coast and after picking up a few fragments of sandstone on the beach, containing *Holoptychius* scales, succeeded in discovering the fish bed *in situ*, on the south side of Woodhill Bay. Proceeding along the shore the unconformity of the Triassic breccia on the Old Red Sandstone was displayed in perfection along the magnificent cliff section. At one point the Trias beach-deposit was seen abutting against, and indeed to a slight extent underlying, the old Carboniferous cliff, at the foot of which it had been formed; while, close by its side, a recent beach similarly disposed against a recent cliff afforded a striking illustration of its method of formation, and bore speaking testimony to the doctrine of uniformity. The walk continued for a considerable distance beneath the cliffs, the unconformity continuing all the way, till we ascended the cliff and walked to Leedy by the path along its edge. At Leedy we halted for a while and Prof. Sollas pointed out the line along which the old post-Carboniferous plain of marine erosion sloped from the Mendips, over Bleadon, grazing the Steep Holme, and then the Flat Holme, till it ended a little below the sea-level, beneath the Trias at Penarth, on the opposite coast, which

could be just seen, thence to rise again into the coal-field of South Wales.

One division, after climbing up Walton Hill, was rewarded by a richly-diversified view over the beautiful valley to the east, and the Channel on the west; the other division continued the walk to Clevedon, examining the interesting quarries of Dolomitic conglomerate which occur on the left-hand side of the road. Galena and green carbonate of copper were obtained from the Dolomite; and the included pebbles of Carboniferous Limestone known by the quarrymen as "Cockles," gave rise to a little discussion, members being at first scarcely prepared to admit that they were foreign inclusions. On the south of Clevedon the Carboniferous Limestone was reached, and the numerous fossils beautifully weathered out upon its surface afforded half an hour's play to the hammer.

WEDNESDAY.—Aust Cliff. The train was taken for New Passage, and under the guidance of Mr. Pass the party made its way to the shore at Aust Cliff, where the section was carefully made out.

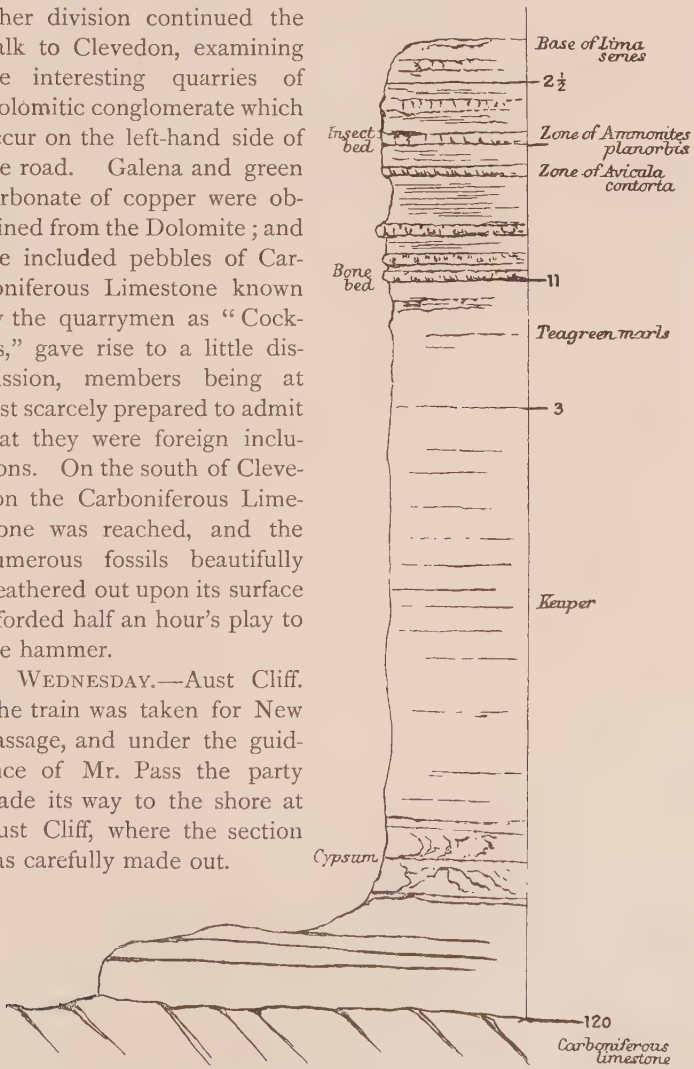


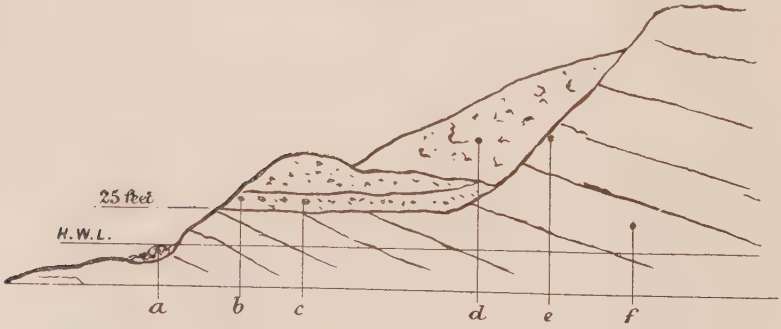
FIG. 125.—SECTION OF AUST CLIFF.

By great good fortune several large blocks of the bone bed were found on the beach, and these, on being broken, afforded the usual fish remains. Dr. Hinde was successful in finding one of the most perfect specimens of *Ceratodus* tooth which this locality has afforded. Most of the party deserted the cliffs for Tintern Abbey, but the rest continued their work on the bone bed, and afterwards visited Patchway. At this cutting literally nothing could be seen, for since it was worked by Etheridge and others it has become completely overgrown with a thick coating of turf.

THURSDAY. — Weston-super-Mare, Uphill. Weston was reached by train and drags were in readiness to take us to Woodspring Abbey; arrived there we spent a few minutes in looking over the ancient but well-preserved Tithe-barn and then, under the guidance of the Rev. H. H. Winwood, walked to the end of Swallow Cliff, where Mr. Winwood delivered an address on the geology of the district. Returning, we soon found the bed of amygdaloidal lava and volcanic ash with organic remains, conformably interbedded in the Carboniferous Limestone, which was found to dip at 40° to the south; immediately beneath the lava it showed signs of alteration, as if baked. The adjacent raised beach, consisting of well-rounded pebbles, with masses of shells filling up the interstices, was next examined. Its height above ordinary spring-tide high-water level is twenty-five feet.

The party now divided; some walked along the line of sand-dunes which bound the head of the bay; observed further on a

FIG. 126.—RAISED BEACH IN BIRNECK COVE, WESTON-SUPER-MARE.

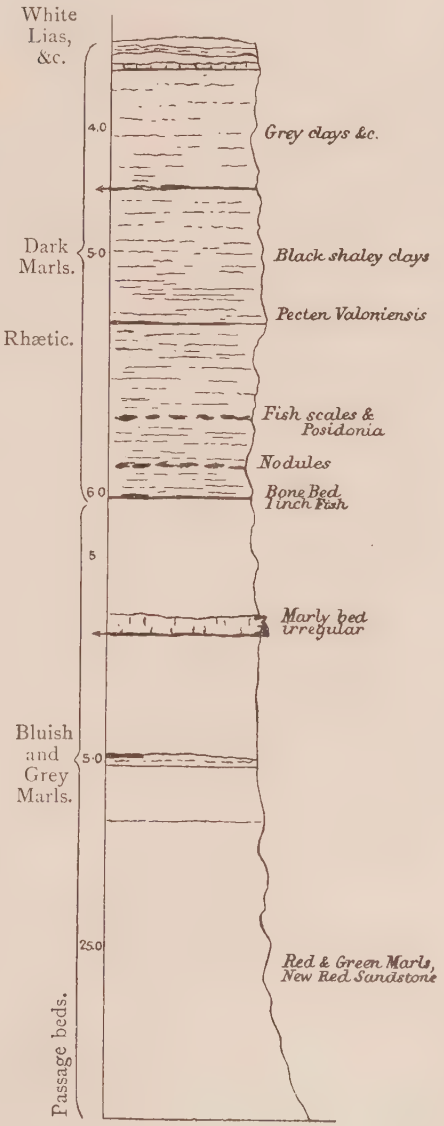


H.W.L. High water level. *a.* Modern Beach. *b.* Ancient Beach. *c.* Ancient Sand Dunes. *d.* The "Head." *e.* Ancient Cliff. *f.* Carboniferous Limestone.

FIG. 127.—UPHILL. (LENGTH OF CUTTING ABOUT HALF A MILE.) [Saunders.]

a. Lower Lias. *b.* Penarth beds. *c.* Red Marl. *d.* Dolomitic Conglomerate. *e.* Carboniferous Limestone. *f.* Trap Beds. *F.* Fault.

FIG. 128.—UPHILL SECTION.

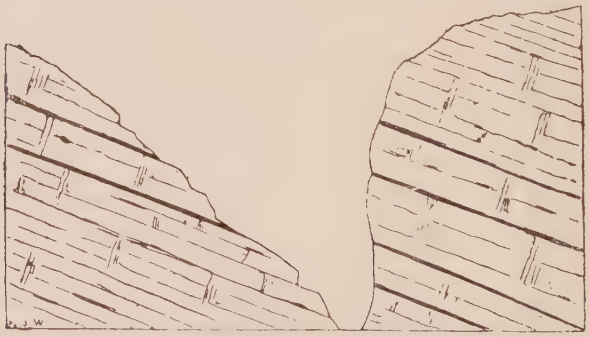


shelly beach, similar in character to that of Swallow Cliff, now in process of formation at the present sea-level, and then waited at Birnbeck Cove for the rest of the party, who soon joined us. Here we were able to study, with complete success, the interesting section of a raised beach and sand-dune, covered by "Head," figured first by Day in 1866.

After lunching at Weston we then drove to Uphill and worked over the cutting on the railway, of which sections are given (Figs. 127, 128). The trap in the Carboniferous Limestone had been freshly exposed and some very fine unweathered specimens were obtained. The Rhætic bone bed was found displaying its usual characters, minus the bones. As there was no promise of obtaining fossils we caught the first train from Uphill station and returned home.

FIG. 129.—DIAGRAM SECTION OF THE CHEDDAR CLIFFS.
[H. B. Woodward.]

N.W. S.E.



(Reduced from Geological Survey Memoir.)

FRIDAY.—Cheddar, Wookey Hole, and Wells. Cheddar caves were first visited. In one we found the cave-earth still remaining and a short search brought to light numerous embedded bones. We next were shown over Cox's Stalactite Cavern and then proceeded up the gorge, observing on the way the identity in dip of the Limestone beds on each side of it; a measurement gave 20° on one side and 22° on the other. The party now divided. One group took train to Wells, the other walked over the Mendips through the village of Priddy, where they saw one of the springs which supply the river Axe flowing out into a swallow-hole, and

descended over the Lower Limestone Shales, down the ravine which lies west of the Ebbor rocks, and in which the Old Red Sandstone lies faulted against the Carboniferous Limestone (some returned to see the Ebbor rocks), and all this party reached Wookey Hole just as the other division was coming out of it. The cave was well illuminated, so that, in addition to the evidence of deposition afforded by the stalagmite the signs of erosion could be plainly traced in the waterworn aspect of the walls. Joint blocks which appeared to have quite freshly fallen were noticed on the floor, and so the recession of the roof might be said, without undue exaggeration, to have been seen in progress. On emerging from the cave attention was called to the ravine into which it opens. The connection of the two required no comment, a clearer instance of a ravine which is simply "a cavern unroofed to the light of day" would be difficult to find. We examined the Trias conglomerate surrounding the mouth of the cave and welcomed to the light the river Axe, which we had last seen, or at least a part of it, falling down the swallow-hole of Priddy.

SATURDAY.—Radstock. On Saturday the Association visited Radstock under the guidance of Mr. Whidborne. They started along the line (by permission of the Great Western Railway Company) to Huish Quarry, and, after examining the section there, adjourned to the neighbouring colliery, where they obtained an interesting series of coal plants, including a fine *Lepidostrobus*. They then visited in order the Lias Quarries at Clandown, Bowldish Mungar and West Tyning, finishing the day at the latter place by examining another coal-heap. Here Prof. T. Rupert Jones pointed out the difference in the aspect of the "Upper" and "Under" Clays, and drew attention to certain interesting glassy surfaces caused by air-bubbles, which had risen from the decaying vegetation, but being unable to escape had ultimately been crushed down between the laminæ to a mere film that just prevented the opposite surfaces from amalgamating.

The various Lias quarries showed well the "poverty of sediment" in this locality during the time of its formation; even in proximate quarries different zones being totally absent, so that the Middle Lias lies on the Lower in a kind of "false unconformity."

Amongst the fossils found was *Rhynchonella oolitica*, an Inferior Oolite species, which has been identified by Davidson (Oct., 1878) from the Middle Lias in this place, and one or two other brachiopods of very unusual shapes.

References.

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New Ordnance Survey. Sheets 264, 265, 279, 280, 281, 296. 1*s.* each.

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[The *Mendip Hills* were again visited in August, 1890. Directors, Rev. H. H. Winwood and H. B. Woodward.]

EXCURSION TO STROUD AND MAY HILL.

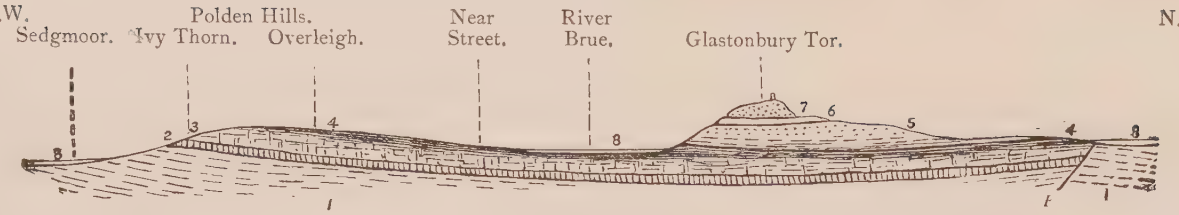
May 9th and 10th, 1870.

Director—Prof. J. Morris, F.G.S.

(*Proc. Vol.* ii. *p.* 33.)

The party proceeded to Stroud and, accompanied by Professor Morris, examined sections of the successive formations, from the

FIG. 130.—SECTION THROUGH GLASTONBURY TOR.



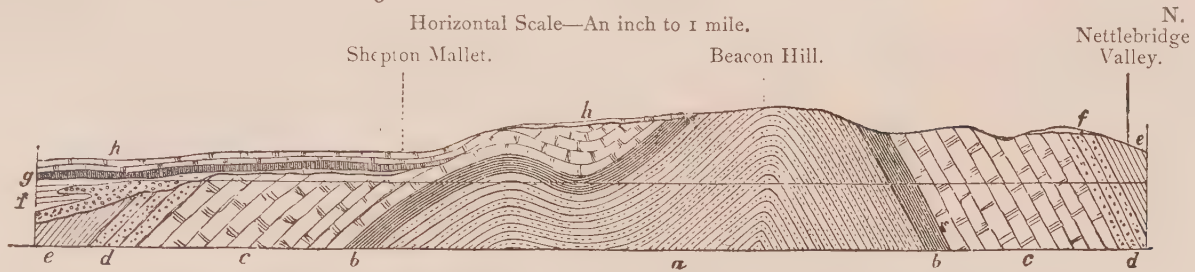
4. Clays. } Lower Lias.
3. Limestones. }
2. Rhætic beds.

1 Keuper Marls.
F. Fault.
8. Alluvium.

7. Midford Sands.
6. Upper Lias.
5. Middle Lias.

[H. B. Woodward, "Geology of England and Wales." Edit. 2.]

FIG. 131.—SECTION ACROSS THE MENDIP HILLS.



h. Lower Lias. *g.* Rhætic or Penarth beds. *f.* Red Marl and Dolomitic Conglomerate (Keuper). *e.* Coal measures. *d.* Millstone Grit. *c.* Upper Limestone Shale and Carboniferous Limestone. *b.* Lower Limestone Shale. *a.* Upper Old Red Sandstone.

[H. B. Woodward, "Geology of England and Wales." Edit. 2.]

Lower Lias to the Great Oolite, of which the vales and hills of this beautiful district are formed. The Inferior Oolite is here very fossiliferous, and good specimens of *Terebratula fimbria*, *Terebratula globata*, *Rhynchonella spinosa*, *Gryphæa sublobata (Buckmani)*, *Pholadomya fidicula*, and *Trigonia costata* were procured.

The physical features of the district were explained by Professor Morris, who subsequently pointed out a bed of gravel containing remains of *Elephas primigenius*.

On the following day the party proceeded to Longhope, on the west of the Severn valley, where Upper Silurian strata are well exposed. A good section of Ludlow rocks is seen in a quarry opposite the railway station, and here the characteristic fossils of this formation are met with, the most abundant species of which is, at this place, *Chonetes striatella*. The remarkable hill, May Hill, was then ascended. This ascent takes the observer over Ludlow, Wenlock, and Upper Llandovery strata, the last-named being the May Hill sandstone and grits, at one time thought to be of Caradoc age.

Many Brachiopods, including *Atrypa reticularis*, *Meristella tumida*, and *Strophomena depressa*, as well as several corals, such as *Halysites catenularis*, *Favosites gothlandica*, *Cyathophyllum* and *Omphyma* were found in the quarries on the side of the hill. Remains of the trilobites, *Calymene Blumenbachi* and *Phacops caudatus*, were also obtained.

FIG 132.—SECTION ACROSS MAY HILL.

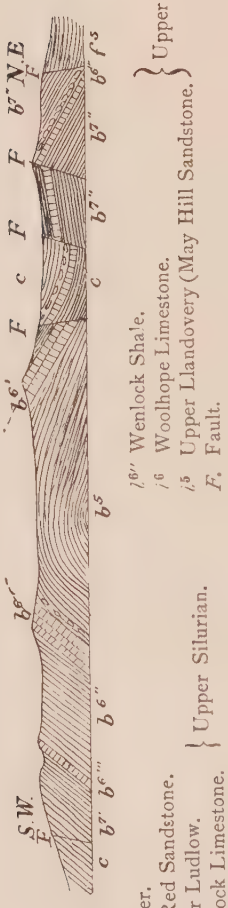
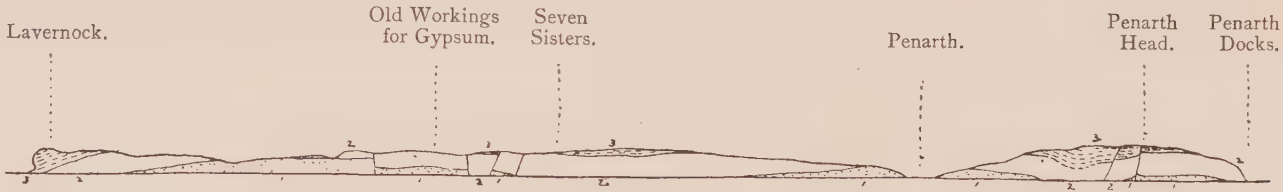


FIG. 133.—SECTION FROM STROUD TO CIRENCESTER. (ABOUT 15 MILES.)

1 Lower Lias. 2. Middle Lias. 3. Upper Lias. 4. Cotteswold Sands. 5. Inferior Oolite. 6. Fuller's Earth. 7. Great Oolite. 8. Forest Marble. 9. Cornbrash.

FIG. 134.—SECTION FROM LAVERNOCK TO PENARTH.



1. New Red Marl. 2. Rhætic beds. 3. Lower Lias.

The view from the summit of May Hill, 965 feet above the level of the sea, is very extensive, and unusually interesting; for here the observer stands on a Silurian island of the old Mesozoic sea, and looks from this Upper Llandovery elevation over Wenlock and Ludlow rocks, over the Old Red Sandstone country of Herefordshire, and the coal-fields of the Forest of Dean; over Triassic rocks, and over the wide Liassic vale of Severn away to the Oolitic escarpment of the Cotteswold hills.

The third day was occupied by visits to Swindon in Wiltshire, and Faringdon in Berkshire.

[An excursion to *Cirencester*, *Stroud*, and *Minchinhampton* took place at Whitsuntide, 1887, the Directors being Prof. Allen Harker and Edwin Witchell. An account may be seen in Proc. vol. x. p. 157.]

EXCURSION TO THE CHELTENHAM DISTRICT.

JULY 20TH, 21ST, 22ND, 23RD, 24TH, AND 25TH, 1874.

Directors—Dr. THOS. WRIGHT, F.G.S., the Rev. W. S. SYMONDS, M.A., W. C. LUCY, and J. LOGAN LOBLEY, F.G.S.

(*Report by* J. L. LOBLEY.)

(*Proc. Vol.* iv. *p.* 167.)

VALE OF SEVERN.

MEMBERS arrived at Cheltenham and were entertained at luncheon by Dr. Wright. That a general idea of the geology and physiography of the district might be obtained as early as possible the afternoon of the first day was devoted to a visit to Churchdown Hill, an outlier of the Jurassic rocks of the Cotteswolds, standing well out in the Vale of Severn, a few miles south of Cheltenham. The summit was reached after a somewhat steep ascent, and the atmosphere being clear a fine view of the great Vale of Severn was obtained. The Palæozoic western boundary from the Malverns to May Hill and the Forest of Dean was equally conspicuous with the Mesozoic Cotteswolds and their two outliers of Breedon Hill and Robin's Wood Hill on the eastern side, while the flat-bottomed vale of Trias, Lias, and Alluvium stretched far to the north and far to the south, with, in the midst, the Severn flowing past Worcester, Tewkesbury, and Gloucester, and broadening to its estuary. After describing the geology of the country within view Dr.

Wright pointed out that Churchdown Hill was a typical outlier, and corresponded stratigraphically with the lower portion of the Cotteswold escarpment, from which the outlier is distant about a mile, the base being composed of the Lower Lias, succeeded by the Middle Lias, with a small amount of Upper Lias forming the summit. Descending the hill a visit was paid to the vicarage, where the Rev. Dr. Smythe, F.G.S., exhibited to his visitors a collection including local Liassic fossils. The party then returned to Cheltenham.

The Cotteswolds.

On Tuesday morning the members proceeded in carriages to Leckhampton Hill, at the foot of which they alighted, and walking up the road obtained extensive views of the beautiful and well-wooded vale, with the wide-spreading town of Cheltenham, overshadowed by the neighbouring Cotteswolds. About midway to the summit Dr. Wright, with maps and sections spread on the hill-side, described the Jurassic series of Gloucestershire, one member of which—the Inferior Oolite—is typically represented at Leckhampton Hill, and is exposed as follows:—

Zone of Ammonites Parkinsoni } Ragstones { Upper Trigonia Grit, Gryphite Grit, Lower Trigonia Grit
" " Humphriesianus }

Zone of Ammonites Murchisonæ, Freestone Division { Upper Freestone, Oolite Marl, Lower Freestone, Pea Grit

At Frocester Hill and Nailsworth the sands above the Lias are well seen, and these Dr. Bright considered to be the equivalents of the Midford Sands, and of the similar sands in Dorsetshire, which in that county underlie the zone of A. Murchisonæ. The upper portion of the hill is very steep. The "Pea Grit" was well seen resting on the Upper Lias, the highest point of which was found. The geologists at length reached the Gryphite Grit and the Upper Trigonia Grit at the summit. Fossils were abundant. Leaving the edge of the escarpment the members made their way across the elevated plateau, the water-parting between the Severn and the Thames. Soon the land began to decline towards the east, and the head of the great Thames basin was found to be a beautiful elongated and narrow dell covered with velvety turf, studded with small, graceful trees, and gradually widening until the Cheltenham and Cirencester high road is struck. Near this point, in a little hollow by the roadside, the far-famed "Seven Springs,"

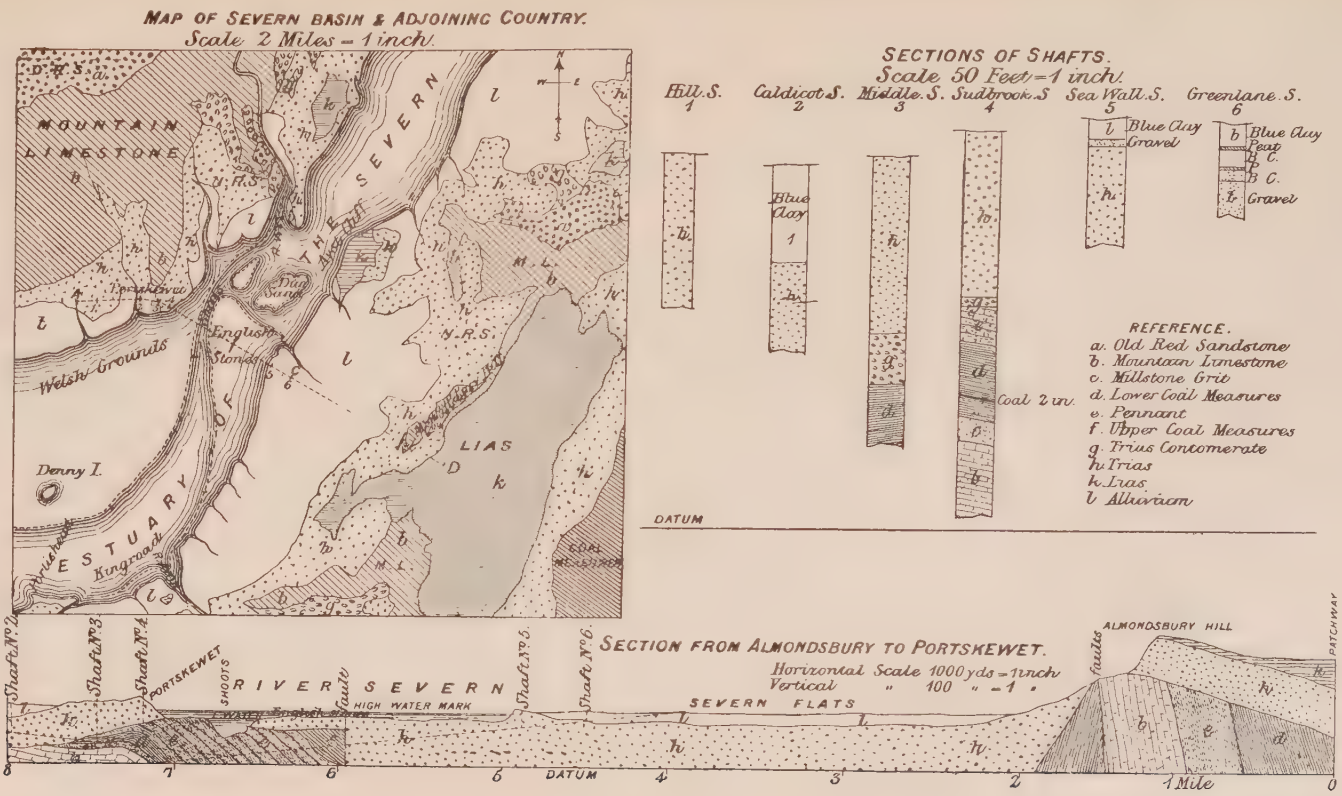


FIG. 135.—MAP AND SECTIONS OF THE SEVERN VALLEY, ILLUSTRATING THE GEOLOGICAL FORMATIONS PASSED THROUGH IN THE CONSTRUCTION OF THE SEVERN TUNNEL.

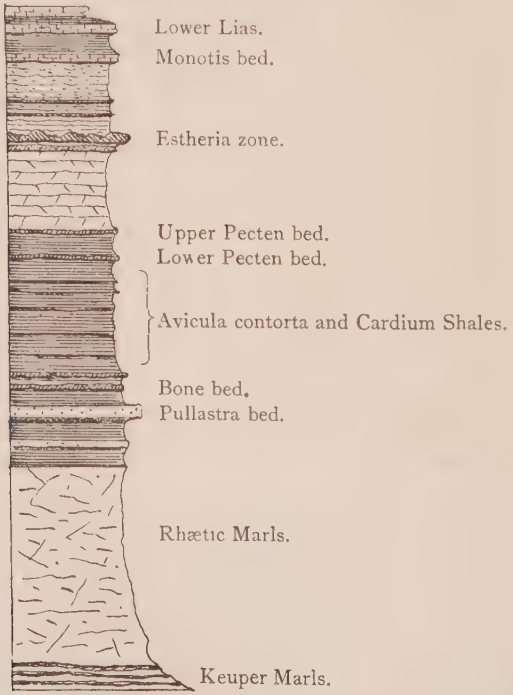
one of the sources of the Thames, were found. The pool formed by water issuing from the springs, which were with difficulty counted as seven, is very small, and the stream running from it—the infant Thames—is a diminutive rivulet that a boy may step across. No sooner is the river born, however, than it is set to work, the stream being utilised for a mill a few yards from its source. The British name Coryn (now Churn) anciently given to the stream signifies the top or summit, and so was applicable to the head waters of the Thames. The members took their departure from the interesting spot, and, regaining the carriages, were conveyed to Cheltenham.

May Hill.

Having surveyed the Severn Valley from Churchdown Hill, and made themselves acquainted with the geology of the great Cotteswold escarpment on its eastern side, the members devoted Wednesday to the Palæozoic rocks forming the western boundary of the vale. The clump of firs crowning May Hill had formed a striking object in the view from Churchdown and Leckhampton Hills on the two preceding days, and this on the third day became the destination of the party. Journeying by way of Gloucester city the geologists crossed the Severn, with the wide alluvial flats on either side, and afterwards entered the valley between the Forest of Dean and May Hill, and alighted at Longhope Station. An exposure of rock in an old quarry close to the railway station showed highly inclined Upper Ludlow strata, which here rise from beneath the Old Red Sandstone forming the valley to the south, and extending to the Carboniferous rocks of the Forest of Dean. The little brachiopod, so characteristic of the Upper Ludlow, the *Chonetes striatella*, is most abundant, and good specimens were easily obtained. On higher ground another old quarry gave an exposure of Wenlock Limestone yielding *Strophomena depressa*, *Favosites gothlandica*, and *Halysites catenularis*. A spur of May Hill was then crossed, and after a slight descent the great symmetrical dome-shaped mass called May Hill was ascended. There are few spots of English ground possessing greater interest to the geologist than the summit of the hill which gave name to an important member of the Silurian system, and which overlooks land formed of every formation from the Cambrian to the Oolites. To quote from Symonds' "The Record of the Rocks," "Nowhere in this part of England is there a nobler view! To the north rise the ancient Malverns, the Silurian rocks of Led-

bury and Woolhope are clothed with wood, and to the north-westward peep out in the distance the Welsh mountains of Old Red Sandstone, with here and there an outlier of Carboniferous rocks telling of the history of denudation beween points so distant as the Pen Cerrig Calch, near Crickhowell, and the Clee Hills in Shropshire. Westward is the Forest of Dean, with its Old Red base, and all the Carboniferous series on its summits; and eastward is the Severn, wandering by the old Norman cities of Worcester, Tewkesbury, and Gloucester, among the battlefields of centuries, by ancient cathedrals, abbeys, and churches, until it expands into its fine estuary; and far away to the south we see its glistening waters bordered by the Cotteswold, the Mendip, and the Quantock Hills." The May Hill Sandstone or Upper Llandovery forms the upper portion of the hill, while Wenlock and Ludlow strata are seen around the base, the whole being probably the result of the same great upthrow of Silurian rocks which formed

FIG. 136.—VERTICAL SECTION OF THE RHÆTIC SERIES AT GARDEN CLIFF, WESTBURY-ON-SEVERN.



the Valley of Woolhope, visited by the Association, July, 1873, May Hill being on the axis of the Woolhope valley, and exhibiting rocks of the same age. The Upper Llandovery rock is well exposed on the hill and consists of beds of sandstone of various degrees of coarseness, in which the little coral, the *Petraia*, presents itself abundantly.

Garden Cliff.

On the fourth day the party, under the guidance of Mr. W. C. Lucy, visited the fine Rhætic and Lower Lias sections of Garden and Fretherne Cliffs on the banks of the Severn, near Newnham. The train was taken to Grange Court, whence a walk brought the geologists to Westbury-on-Severn, and a little further to Garden Cliff. It being low water in the Severn a good general view of the cliff was obtained from a point well in front, and here Mr. Lucy described the section, the details of which he gave as follows :—

		ft.	in.
Lias.—Lower Lias, *A. planorbis*, *Ostrea liassica*.			
Rhætic Series.	Bed with *Modiola minima*	0	3
	Bed with *Monotis decussata*	1	6
	Bed with *Modiola minima*	0	5
	Bed with Fish remains	3	6
	Bed	3	0
	Estheria Zone	1	0
	Bed	0	6
	Bed with *Pecten valoniensis*, *Cardium rhæticum*, *Axinus cloacinus*, *Anatina Suessi*, *Lima precursor*, *Myacites musculoides*, *Pleurophorus angulatus*, *Modiola minima*.	7	0
	Upper Pecten Bed—*Plesiosaurus*		
	Bed	2	0
	Lower Pecten Bed.		
	Avicula contorta Shales	2	6
	Cardium rhæticum Shales	7	0
	Bone Bed, *Acrodus minimus*, *Gyrolepis Albertii*	0	1
	Bed	0	6
	Bone Bed, *Nemacanthus*, *Saurichthys apicalis*, *Pullastra arenicola*	0	1
	Bed	1	6
	Pullastra Bed—*Cardium rhæticum*, *Modiola minima*, *Avicula contorta*, *Pullastra arenicola*	1	0
	Bed	1	10
	Bed, *Gyrolepis Albertii*, *Sargodon tomicus*, *Pullastra arenicola*, *Saurichthys apicalis*, *Avicula contorta*	0	5
	Bed	1	3
	Bed, Coprolites, Teeth, Scales	14	0
	Red Line		
	Bed	3	3
Keuper—Alternating Beds of Red, Grey, and White Marls.			

The dip of the beds allows of each being examined with ease as the observer proceeds along the base of the cliff to the south-east, geologically higher and higher beds forming the lower portion of the cliff. Returning to the north-west end of the cliff the somewhat tired party awaited the boats, which had been ordered to convey them to Fretherne Cliff. At length with the rising tide the boats appeared in sight and all embarked, but time only admitted of a hurried inspection of this fine Lower Lias section, as Severn bank was traversed *en route* to the Berkeley and Gloucester Ship Canal, by which the geologists returned on board a steamer to Gloucester. A visit was paid to the Gloucester Museum in the evening.

Tewkesbury, Apperley, Wainlode Cliff.

The fourth day having been given up to the banks of the Severn below Gloucester, the fifth was occupied by visits to Tewkesbury, Apperley, and Wainlode Cliff on the river above that city. Leaving Cheltenham early the party proceeded by carriage along the Tewkesbury road. At Coombe Hill a good section of the Rhaetic or *Avicula contorta* series was examined, and Dr. Wright explained his reasons for preferring the latter name, originally given by him to these beds, which are so persistently characterised by the *Avicula contorta*, both in this country and abroad. On arriving at Tewkesbury the members were met by the Rev. W. S. Symonds, the Director for this day.

Before leaving the town, Tewkesbury Abbey was visited at the invitation of the Vicar, who read an interesting paper on the history and archæology of the grand old pile, in which many of those slain in the sanguinary and decisive battle of Tewkesbury, including the Prince of Wales and the Duke of Somerset, lie buried. Mr. Symonds then led the way across the "Bloody Meadow," the scene of the slaughter of 4,000 Englishmen, to Tewkesbury Park, the site of the great battle, formed for the most part of the higher-level gravels of the Severn Valley. The old estuary gravels, containing remains of existing Mammalia, slope down to the alluvial river flats.

A walk through the riverside meadows brought in sight the ancient church of Deerhurst, where Mr. James Parker gave a most interesting lecture. He exhibited a rubbing of the dedication stone, of the date 1056, which states Odda to have been the founder. But the tomb of Hugh Strickland, the predecessor of Phillips at Oxford, and the memorial window erected to his memory

rendered Deerhurst Church specially interesting to its geological visitors, who then left Deerhurst for Apperley, Strickland's old home. Crossing the park the river was again reached, and a short walk by its verdant banks terminated at Wainlode Cliff, another fine section of the Rhætic series, first examined by Strickland. Dr. Wright and Mr. Symonds described the section, in which the Rhætic Black shales are very finely displayed. The shales were examined, but few fossils were found.

Returning to Apperley the members were received at Apperley Court by Miss Strickland, the sister of the distinguished geologist, who had invited the party to dinner. Apperley Court commands a view over one of the richest portions of the Vale of Severn, and stands in a park of great beauty. Miss Strickland invited her guests to inspect the collection of mammalian remains obtained from the Severn Valley gravels by her brother.

Stroud.

On the succeeding day, the last day of the excursion, only a small number of members returned to London, visiting *en route* Stroud and its neighbouring hills of Oolite. Those who did so, however, saw to advantage the deep valleys cut through the Great and Inferior Oolites which characterises this part of Gloucestershire. Rodborough Hill of Inferior Oolite, so famous for its abundant fossils, and the Great Oolite quarries on Minchinhampton Common, were examined, and yielded a large number of fossils to the vigorously-used hammers of the party. The train was then taken for London, and the week's proceedings terminated.

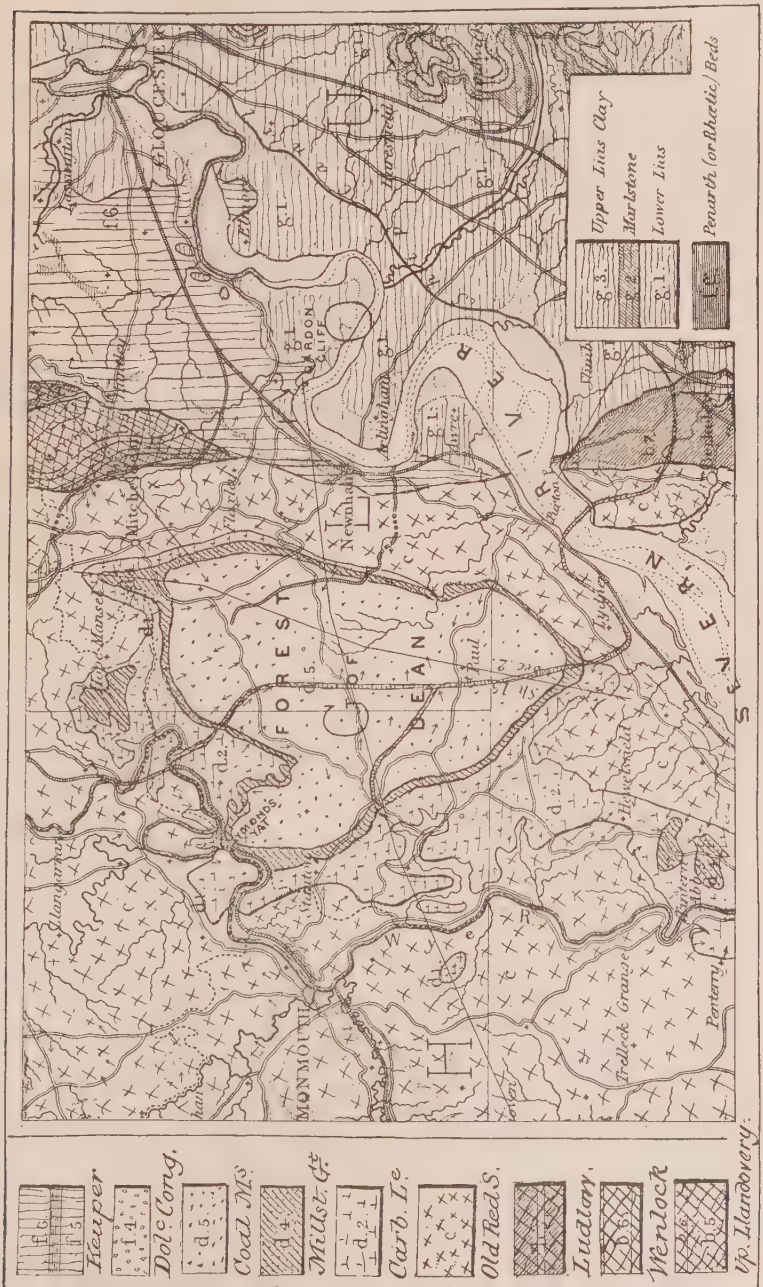
[An excursion to the *Forest of Dean*, *Wye Valley*, and *South Wales* took place on August 6th to 11th, 1888, the headquarters being *Gloucester* and *Cardiff*, and the Directors Messrs. Rudler, Galloway, Gwinnell, Storrie, T. H. Thomas, Vachell, and Wethered. See Report in Proc. Nov., 1888, also Papers by Messrs. Wethered, Gwinnell, H. B. Woodward, and Rudler.]

References.

Maps.—Ordnance Survey. Geological. Sheet 35. 8*s.* 6*d.*
New Ordnance Survey. Sheets 216, 217, 233, 234, 235, 250, 264. 1*s.* each.
Books.—Etheridge, R., On the Rhætic Deposits of Penarth and Lavernock. Rep. Cardiff Nat. Soc., vol. iii. 1872.

FIG. 137.—GEOLOGICAL MAP OF THE CARDIFF DISTRICT, AND THE SOUTH WALES COALFIELD. [For index to beds see fig. 138.]

FIG. 138.—GEOLOGICAL MAP OF THE FOREST OF DEAN, AND PART OF THE WYE VALLEY. (Four miles to the inch.)


Upper Lias Clay
Marlstone
Lower Lias
Penarth (or Rhætic) Beds
FOREST OF DEAN
SEVERN
MONMOUTH
GLOUCESTER
Newnham
Littledean
Mitcheldean
Drybrook
Ruardean
Coleford
Parkend
Lydney
Berry Hill
Pillowell
Broadwell
Nailbridge
Hewelsfield
Redbrook
Penterry
Trelleck Grange
Staunton
Llangwm
Llanvihangel
Tintern
Woolaston
Aylburton
Purton
Broadoak
Blakeney
Awre
Newnham
Upton
Minsterworth
Highnam
Churcham
Hartpury
Maisemore
Tuffley
Robins Cliff
Woods Cliff
Kempley
Dymock
Newent
Taynton
Huntley
Longhope
Hartpury

Etheridge, R., On the Rhætic Beds at Garden Cliff. Proc. Cotteswolds Nat. Field Club, vol. iii., 1865, p. 218.
Woodward, H. B., Geology of England and Wales, ed. 2, 1887. (Forest of Dean, p. 191; South Wales Coal Field, p. 193; Rhætic Beds, p. 248; Drift, p. 493.)
[Numerous Papers in the Proceedings Cotteswolds Nat. Field Club.]

DEVONSHIRE AND CORNWALL.

EXCURSION TO SOUTH DEVON.

JULY 21ST, 1884, AND FIVE FOLLOWING DAYS.

Directors—A. CHAMPERNOWNE, F.G.S., W. PENGELLY, F.R.S., and R. N. WORTH, F.G.S.

(*Report by* R. N. WORTH and A. CHAMPERNOWNE.)

(*Proc. Vol.* viii. *p.* 458.)

THE district chosen as the scene of the long excursion of 1884 is one of peculiar interest to the geologist. The greater part of South Devon is occupied by rocks of the Devonian system, and nowhere can the Devonian limestones be studied to better advantage than at Plymouth and Torquay. On the north of the area is the wild granitic expanse of Dartmoor, flanked by the rocks of the great Carboniferous trough of Central Devon. On the extreme south lies the Bolt Head promontory, consisting chiefly of metamorphosed schists which have been variously assigned, and are now suggested as Archæan. The Triassic rocks of the west extend in mass to Torbay, and reappear as small outliers within the district, at Thurlestone and Cawsand. Associated with the various systems are igneous rocks of singular scientific importance, chief among them the series of which the volcanic peak of Brent Tor forms the most notable feature. The Dartmoor granite is skirted by a belt of altered rocks of a widely varied and highly interesting character, and is intersected by numerous elvan courses and lodes. The recent geology of the area, moreover,

is made specially noteworthy by the occurrence of raised beaches, submerged forests, and bone-caves—the latter including the caverns of Oreston, Kent's Hole, and the Brixham Windmill Hill Cave.

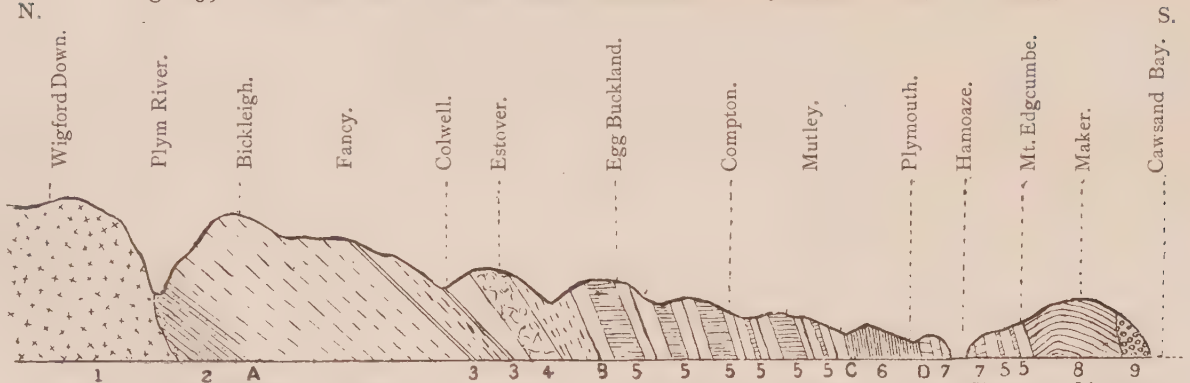
Monday.—The Director of the Plymouth district conducted the members to the famous Hoe, and from that point of vantage called their attention to the leading features of the geology of the country commanded. The summit of the Hoe, he explained, was nearly the central point of the most important development in the Plymouth area of the limestones of South Devon, commonly classed as Middle Devonian. Below, to the north, lay a mass of shales and slates, in which he recognised three successive divisions —one associated with lodes and elvans; a second largely mixed with interbedded lava and ash beds; and a third composed of more compact slates, purple and green in colour. (Fig. 139.) At several points the slates graduated up into the limestones through calcareous shales; but at others there was a band of trap rock in close proximity to the limestone, which occasionally produced alterations in its character. The limestone itself formed a ridge about half-a-mile in width, the upper surface of which had a wall-like or terraced character—a platform of denudation—which was not peculiar, however, to the calcareous beds of Plymouth. Several features in the occurrence of the limestone pointed back to its origin as a fringing coral-reef, and its organic remains were largely disposed not so much in horizons as in areas—corals, bivalves and univalves having their own associations. Though the limestone band was composed of the hardest rocks in the locality, it was broken through at several points, as where it was passed by the Tamar and the Plym, and at Stonehouse Creek, Mill Bay, and Sutton Pool. These openings, though mainly worn and eroded by subsequent causes, originated, he believed, in the operation of forces which had greatly disturbed the strata to the south. The depth of the river-channels within the limestone was remarkable. At Laira Bridge the bed of the rock was eighty feet below high-water mark, but immediately adjacent to the Hoe there was a depth of over 160 feet; in fact, it was precisely within the limits of the limestone that the greatest depths in the harbour and its branches were to be found.

As the main characteristic of the rocks directly north of the limestone was slate, so that of the rocks immediately to the south was sandstone. The twin elevations of Staddon and Maker Heights, east and west of Plymouth Sound respectively, were

composed of red and grey Devonian sandstones and grits, which the Director was inclined to correlate with those of Pickwell Down in North Devon. Associated with them were some patches of highly fossiliferous shales. These southern grits and their connected slates were much contorted and disturbed; in fact, Professor Phillips had called the contortions at Staddon "amazing," and Professor Jukes, while giving up their solution as hopeless in the time at his disposal, suggested that possibly these apparently overlying rocks might be really underlying, and brought up by an anticlinal accompanied by inversion and contortion. This view the Director did not accept. The displacements of the rocks on the west of the Sound were partially caused by the occurrence of a mass of intrusive Triassic trap, which was associated with a patch of Triassic breccia and conglomerate, the most westerly outlier of the Trias in the country. The contortions on the east of the Sound were, however, more marked, and accompanied by what seemed traces of metamorphism. This was possibly to be connected with the fact that the Channel contained a large submarine area of granitic or granitoid rocks. The Eddystone reef, the lighthouse crowning which was seen on the horizon, was a mass of gneiss and allied rocks, and there was some evidence that these rocks extended into Plymouth Sound, and formed part of the Shovel Reef, on which the Breakwater was built.

Turning to more recent geological phenomena, the Director pointed out the limestone quarries at Oreston, where, in 1816, the first bone-cave which was made the subject of scientific enquiry was found. Fissures on the Hoe had also proved ossiferous. Besides this they had, contiguous to the Hoe, at Sandy Cove, in Mill Bay, the remains of a submarine forest, and on the Hoe itself was one of the finest examples of a raised beach in the country. By a fortunate coincidence, after having been hidden for some forty years, the beach had again been exposed within the past few weeks. At the finest section there were eighteen distinct beds of sand and pebbles, between the bouldered rock-masses which lay immediately above the limestone shelf on which the beach rested and the head of surface soil. The beach had been confounded with a totally distinct set of deposits on the top of the Hoe, and at other points on the limestone plateau. Huge cavities or pockets in the limestone were filled with sand and clay and water-worn stones, and it was assumed that these alluvia and the beach were identical. One suggestion was that they were

Fg. 139.—Generalised Section from Dartmoor to Cawsand Bay. 12 miles.



1. Granite. 2. Altered Rocks. 3. Elvan. 4. Greenstone. 5. Volcanic Rocks. 6. Purple and Green Slates. 7. Limestone. 8. Grits 9. Felspathic Triassic Trap associated with Triassic Breccia and Conglomerate.

The rocks from the moor to the sea generally dip southward at angles increasing from the granite; northerly dips are few, but there are frequent repetitions which can only be worked out satisfactorily by very detailed mapping.

A to B, Buckland and Bickleigh beds. The lowest group of the Plymouth series, grey and drab slates with lodes and elvans, probably to be correlated with the Combe Martin of North Devon.

B to C, Weston and Compton beds. Slates with interbedded volcanic matters in great variety—lavas and ashes and slaggy rocks, often graduating into the shales. There is unquestionably much repetition here, and Mr. Rutley's suggested identification of the volcanic rocks with those of Brent Tor seems highly probable.

C to D, Mutley beds—frequent repetitions.

The limestone rocks contain bone caves. The lava and ash beds at Mount Edgcumbe are associated, as in B to C, with shales; and the grits, which seem to correspond with the Pickwell Down sandstones, are much disturbed by some cause near at hand.

The existence of granitic rocks in the Channel area has been shown by Mr. A. Roope Hunt, F.G.S.; and the Eddystone Reef is a typical gneiss; while there is evidence that the Shovel Reef in Plymouth Sound is in part gneissic also.

both "Northern Drift." No geologist, however, who had ever examined the two could confound them. The summit and fissure beds were distinctly alluvial, the high-level deposit of an ancient river. Their character, moreover, was well marked. The clay occurred in patches, mingled with veins and beds of sand. The pebbles ranged from a very small size up to a dozen pounds in weight. They were chiefly quartzose, some schorlaceous, a few granitic or granitoid, some of a dark hard hornblendic or altered slate. An occasional pebble of trap or basalt, and a few flints (Greensand?) also occurred.

The raised beach possessed no single one of these characteristics. There was no clay, the sand was of a totally distinct nature and origin, and the pebbles, instead of having been derived from a distance, were wholly composed of the rocks at present exposed on the shores of the Sound. The most remarkable feature was that limestone *débris* was scarce, and that the material had evidently come from the westward. The Triassic trap of Cawsand was, as a rule, the rock most largely represented; while one boulder of at least two hundredweight came from a Devonian trap exposure at Drake's Island. All this pointed to a very different contour of the Sound at the raised beach period than that which would *primâ facie* have been anticipated.

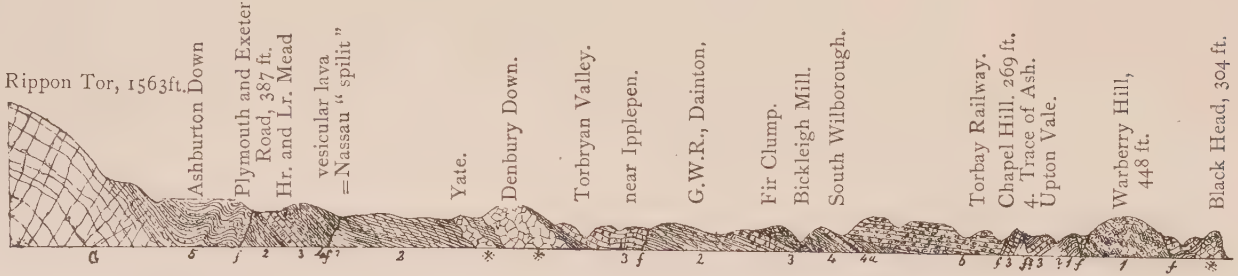
The raised beach, so fortunately recovered to sight, having been inspected with much interest, the party proceeded by boat to Deadman's Bay quarry, which had been chosen by the Director as illustrative of the Cattedown limestone quarries, not only because it was the nearest of the series, but because of the peculiarities of stratification which it presented, some of the beds being approximately horizontal and others nearly vertical, as opposed to the usual southerly dip, and others again being faulted, while the crest of the quarry showed the shallow Cattedown synclinal to great advantage. By way of illustrating the character of the alluvial deposits described in connection with the Hoe, and the absolute dissimilarity between them and the raised beach, the Director called attention to a great fissure or pocket, the side of which had been opened out in some of the older workings, and identified some of the pebbles dug out as belonging to rocks of the Dartmoor border series. The weathered corals with which the older portions of the quarry abound were much admired.

The evening was wound up in the Museum of the Plymouth Institution, the Council of which had invited the members of the Association to a *conversazione*.

FIG. 140.—SECTION FROM RIPPON TOR, DARTMOOR, THROUGH DENBURY DOWN TO THE BLACK HEAD, TORQUAY.

About fifteen miles. Vertical scale exaggerated.

N.W. S.E. E.S.E.



6. Triassic breccio-conglomerates.
5. Culm series; shales, sandstones, and black cherts.†

Upper Devonian
- 4A. Bands of red limestone and shales.‡
- 4. Diabase tuffs, schalstein, &c., with nodular shale and coarse slate.*

3. Middle Devonian limestone (Stringocephalus beds).
2. Clay-slates, locally purple and green, fossils rare, no grits.
1. Lower Devonian; tough grauwacke grits and sandy schistose beds (fossils of "Spiriferen-sandstein," notably *Homalonotus* and *Pleurodictyum*).

* Eruptive rocks. G, Granite. *f*. Faults.

† Group 5 rests unconformably on 3 and 4 within a mile north of the middle of the section.

‡ On the same horizon as the Ramsleigh reef-limestone (calcaires de Frasnes).

* Equivalent to Sandberger's "Diabas-gesteine der Mittleren und oberen Gruppe."

The Museum, which has been recently built, is a very fine room, and contains a large and good local geological collection. Among the more notable features are some of the original specimens by which the Rev. R. Hennah established the fossiliferous character of the lime rocks of Plymouth, and a fine suite of Carboniferous fossils from North Devon, presented many years ago by General Harding. All the bone caves of Devon have contributed to the collection—from the discoveries of Whidby at Oreston; Northmore and McEnery at Kent's Hole; Moore at the Hoe, and Bellamy at Yealmpton, to the more modern results of investigation by Spence Bate at Stonehouse, and the Director's own discoveries at Stonehouse and Pomphlet.

Tuesday.—The following day was devoted to Totnes and Dartington, the Director being Mr. Champernowne. Leaving Plymouth by train, a halt was made at Totnes to inspect the antiquities of that notable old town. The castle, church, walls, and gates, the remains of the Priory, the ancient Guildhall, and last, not least, the quaint piazzas—which, if at some distance, never fail to recall Chester to those who are familiar with the "rows"—each and all lent their quota of interest.

From Totnes the party walked to Dartington Hall, the seat of the Director, a distance of two miles. The earliest records of Dartington relate to the time of Edward the Confessor, for from Doomsday Book we learn that "Alwin held it in his time." At the actual time of the Domesday Survey (1086) we have "William de Falaise holds Dertrintone, Cockingtone, Rattrew, and other manors. . . ."

In the sixteenth century Sir Arthur Champernon, the younger son of Sir Philip Champernon, of Modbury, made it the place of his dwelling. A monument in the old church tower, bearing date 1578, is to his memory. Dartington has since continued in this family.

This place is situated on a varied group of the Devonian system which clearly succeeds the Middle Devonian limestone in ascending order, and the principal rock exposures in this depressed and faulted district were shown and explained by the Director as well as the time and difficult stratigraphy would permit. (See Figs. 141 and 142.)

But it may be well, before describing the route, to say a few words on the country extending eastward, and slightly exceeding the area studied. A key to this broken bit of country is found in

FIG. 141.—GEOLOGICAL SKETCH MAP (11 SQ. M.) NEAR TOTNES.

(From a Drawing by A. CHAMPERNOWNE, F.G.S.)

Scale—One inch to a mile.

Alluvium.

Terraces (more or less distinct) with older Dart gravels.

Berry Park and Upper Dartington slaty shales, succeeded by purple grits farther eastward.

Middle Devonian limestone; and subordinate layers both above and below.

All the slaty rocks below the Dartington limestone.

Contemporaneous igneous rock of all kinds.

Eruptive igneous rocks (dolerite, &c.).

Mostly faults, a few doubtful boundaries.

The queries (?) indicate some doubt as to which of the slaty masses the beds belong.

A. B. Line of accompanying section (fig. 142.)

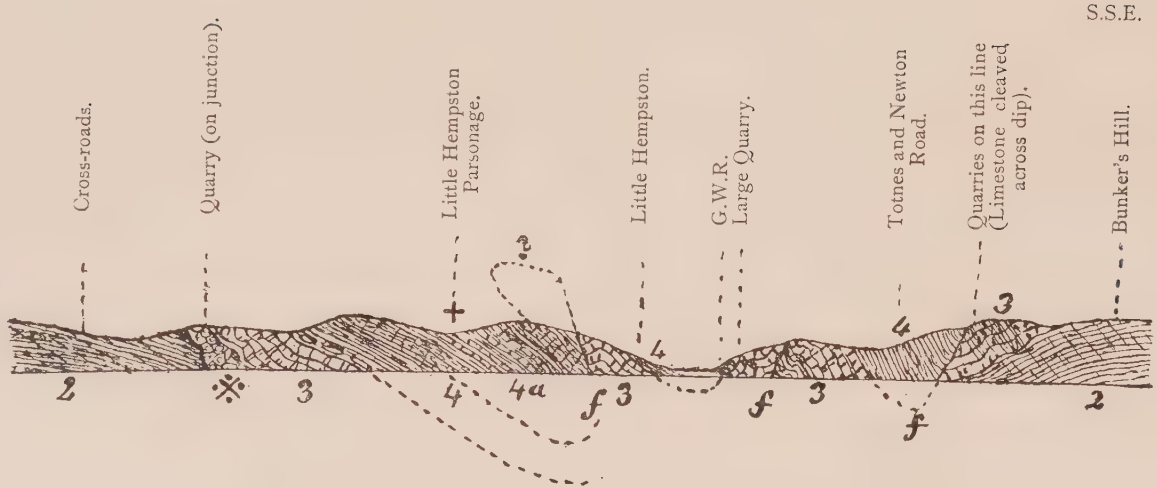
1. Totnes. 2. Totnes Station. 3. Dartington Hall. 4. Little Hempston. 5. Staverton. 6. Church. 7. Belleigh. 8. Berry Pomeroy.

the fact that the slates which on the Dart about Northwood and Staverton are seen to dip under the limestone, again reach the surface at Bunker's Hill, north-east of Totnes, forming a low dome-shaped elevation, from which, on three-quarters of its circumference, the limestones have a quaquaversal dip. The south-western continuation appears to be interrupted by the down-thrown upper beds. Dr. Holl (Quart. Journ. Geol. Soc. 1868, p. 430) recognised the fact that "the slaty rocks between the Buckyatt limestone and Gatcombe House," in other words Dartington and Little Hempston trough, "are above the limestones," but in the following paragraph he expressed great doubts as to the slates between Bunker's Hill and Berry Pomeroy. As to the latter the writer has not experienced this difficulty, notwithstanding some conflicting evidence from cleavage alluded to by Dr. Holl. They are below the limestones, as the section (Fig. 142) shows.

The Berry Pomeroy limestone thus thrown off on the east of Bunker's Hill is overlain by the Berry Park slates, the equivalent of the upper Dartington beds (*Streptorhynchus umbraculum*, Schloth., being common as a cast), and these in turn are surmounted by a series of purple and grey grits and slates, which form the highest ground between the Dart and Torbay, viz,, Westerland Beacon on the north, and Windmill Hill on the south of the Paignton Trias, which thus lies in a hollow. The grits are the same as those of Staddon Heights and Mount Edgcumbe in Plymouth Sound, and doubtless also of the Pickwell Down beds in North Devon, of the Psammites Du Condroz in Belgium, and by probable inference, not perhaps the most satisfactory means, they would represent generally (both stratigraphically and lithologically) parts of the Upper Old Red Sandstone.

To return to the upper Dartington beds—the walk before luncheon was taken across the inverted side of the trough to Hill Park quarry, where some beds made up of corals were pointed out. Thence, turning north and crossing a N.W. and S.E. fault to its upcast side, an exposure of coarse volcanic tuff passing into an ashy slate was seen. The tuff is chiefly made up of slaty-looking fragments, broken and kaolinised felspar crystals and a few quartz grains. This description might pass for a grit; Rutley, however, having examined microscopic sections, has given his opinion in favour of its volcanic origin, for which in the field it would readily be put down. Some of the Nassau schalsteins come very close.

FIG. 142.—SECTION NORTH-EAST OF DARTINGTON.



For references, see legend to section from Dartmoor to Torquay, Fig 140.
Eruptive rock (*) has a rude orbicular structure.
+ Axis of Dartington syncline continued across the Dart.
Length of Section, two miles. Vertical scale slightly exaggerated.

N.B.—The fault west of Little Hempston is a genuine reversed fault, hading under the upcast, it is exposed in the railway cutting on east bank of the Dart opposite Darlington.

The limestone, not well exposed, was then crossed, and an eruptive rock forming the hill crowned by the old keeper's lodge was inspected. It would be premature to assign a name to this rock, which is heavy, abounds in iron pyrites, and, from the sub-translucent aspect of its felspar, was regarded by some of the party as probably less basic than many of the "greenstones" of the neighbourhood.

Thence, recrossing the above-named fault and a corner of the limestone, the escarpment of the upper group was surmounted to the Trigonometrical station, where a good view was obtained and the features indicating the various outcrops pointed out. The ridge was followed to the higher entrance, where the tuff beds are well exposed. A bed containing casts of *Pachypora*, *Cyathophylla*, and *Brachiopoda* was shown, the fossils proving its sedimentary origin. Towards the axis of the trough, a little above the tuff beds, there are many layers of blue limestone, which were pointed out close to the farm entrance, intercalated with slaty shale; the same appear at Little Hempston Parsonage, north-east of the Dart.

After luncheon at Dartington Hall, the next point was Pit Park quarry, in the higher beds of the Middle Devonian limestone, here much dolomitised and disintegrated. One bed, four feet thick, is remarkable for its profusion of Stromatoporoids, and has been alluded to elsewhere. (Quart. Journ. Geol. Soc., 1879, p. 67.)

To give an idea of the richness of this spot the following imperfect list is appended:—

Stringocephalus Burtini, Defr.; *Spiriferina cristata* (var. *octoplicata*), Schloth.; *Cyrtina heteroclita*, Dav.; *Atrypa reticularis*, Linn.; *A. aspera*, Schloth.; *Rhynchonella primipilaris*, V. Buch.; *Hexacrinus* (pelvic plates and stems); *Cyathocrinus geometricus*, Goldf. (plates); *Pachypora cervicornis*, Blainv.; *Alveolites suborbicularis*, Lam.; *A. Battersbyi*, Edw. and Haime; *Alveolites* sp.; *Heliolites porosa*, Goldf.; *Cyathophyllum damnoniense*, Lonsd.; *C. obtortum*, Edw. and Haime; *Heliophyllum*, sp.; *Zaphrentis*, sp.; *Cystiphyllum vesiculosum*, Goldf.; *Stromatopora concentrica*, Goldf.; *Stromatopora*, sp. nov.; *Pachystroma* (at least four species, including *S. dartingtonensis*), Carter; *Caunopora placenta*, Lonsd.

The Brachiopoda are scarce, but the above-named forms have been identified by Dr. Davidson.

Shinner's Bridge quarry, of nearly black fossiliferous limestone in the lower portion, had a few minutes' inspection, and then to

complete the programme the eruptive rock of Yarner Beacon was visited; the soft slates which underlie the limestone being exposed midway. A small piece of fresh rock had been previously opened in an orchard. The rock may be considered a dolerite, consisting of labradorite, augite, viridite and magnetite, or ilmenite.

A break met the party at Lownard Cross, and took them to Totnes station, the round, walking and driving, having been about seven miles.

WEDNESDAY.—Torquay, also reached by railway, was the scene of the labours of the Wednesday and the members were directed by Mr. W. Pengelly, F.R.S., whose labours have made Torquay classical ground with the student of geology. Not merely are the Devonian limestones to be studied there to excellent advantage, but the Triassic series (it was in the "red rocks" here that the curious beekites were first found), and all the leading features of the more recent geological phenomena of the county—cavern deposits, raised beaches, and submerged forests. Starting from the Torquay railway station, the coast was skirted to Hope's Nose, the northern horn of Torquay, the chief objects of interest to be noted *en route* being the submerged forest on Torre Abbey sands, which has yielded not only relics of the mammoth, but evidence of man's contemporaneity in implements of deer-horn and of flint; the place of junction of the Trias and Devonian limestone, the finest illustration of which, however, is that in Babbacombe Bay; the contortions in the limestone at Torquay; the slaty cleavage at Meadfoot; the contorted and cleaved limestone near Hope's Nose, and the raised beach on that headland, first described by Godwin-Austen.

A visit to Kent's Hole, which was planned to succeed the stratigraphical work of the day, was, however, the most anxiously anticipated item.

THURSDAY.—The purlieus of Dartmoor were visited, with the special object of studying the bordering granitic and allied rocks and the altered Devonians skirting them. The nearest station to the moor from Plymouth is Bickleigh, and hence the party had to tramp well-nigh a dozen miles across country to Dousland Barn, where the train was again available for the return journey.

On the way to Bickleigh such of the geological features of the Plym Vale as could be seen from the train were pointed out, including the Cann Elvan; and on alighting, before descending into the vale, a few remarks were made on the general character-

istics of the moor. Special attention was called to the plainness with which the line of junction between the granite and the slate on the face of Shaugh Hill could be traced, by their contrasted rugged and smooth surfaces. The walk to Shaugh Bridge, with its flashing rivers, ancient oaks, and towering crag of semi-columnar granite—the Dewerstone—was delightedly enjoyed. Here the real work of the day commenced. Wigford Down, on the north-west flank of which the Dewerstone rises in all its massive grandeur, projects into the Devonian area peninsular fashion, and is bordered on three sides by rocks, which display in varying degree important illustrations of contact metamorphism. The micaceous schists of Meavy and of Shaugh are brought prominently into notice in the well-known report of the indefatigable De la Beche; but he does not pursue the subject into its minuter details, and indicate the different gradations by which the alteration dies away as we remove from the edge of the granite; nor does he define precisely the extent of the zone of alteration. To do more than he did was, however, impossible at the time, under the conditions that limited his work, and later geologists have enjoyed many facilities which to him were unknown. The altered rocks are now clearly traceable, from their contact with the granite as well-defined micaceous schist—in patches almost gneissic in character—through andalusite schists of varying degrees of "spottiness," until the last indication of change is seen in a slight silkiness of texture which has still its variations and its stages. In the neighbourhood of Ivybridge the andalusite appears more in the form of chiastolite; but chiastolite characters are less distinctly seen on this extreme western edge of the moor; while in some of the altered schists of Cornwood andalusite is developed more strongly than at any other point.

The Director first led the party to an old quarry, which afforded the best available exposure of the altered rocks on their outer verge, and in which the sericitic schists were admirably represented. Thence he made a traverse up the hill to the granite, pointing out the evidence afforded of increasing metamorphism until—in actual contact with the granite—there was found highly micaceous schist passing into a compact felsitic rock of very unusual character.

A rugged walk along the hill-side, thickly strewn with weathered granite boulders, brought the party to the little village of Shaugh. This was the only "refreshment station" on the route;

and here, therefore, a welcome halt was called. From Shaugh the road was followed by the northern flank of the long ridge of Saddleborough to Cadover Bridge; some large blocks of schorlite yielding to the hammer *en route* interesting specimens of achroite and epidote. Cadover Bridge lies in the heart of a characteristic stretch of wild moorland scenery. Here the Director pointed out the obscure remains of an old "streamer's" settlement, and the line of ancient tin streaming works, traces of which abound in the valley of the Plym, was indicated.

Of schorl rocks, granites, and elvans there is a greater variety to be found in the valley of the Plym than at any other point of the moorland. The quarries at the Dewerstone are of an average-grained grey granite of ordinary type; but veins of fine-grained and coloured granites are of common occurrence, and Trowlesworthy Tor contains the finest red granite in mass in the country, granite that can hold its own with the very finest Scotch. Trowlesworthy, too, has yielded that most beautiful of all Devonian rocks, Trowlesworthite, discovered last year by the Director. Moreover, there is much variety in the felsitic porphyries, or elvans, of the district, some of which have almost the fineness of grain and purity of colour of statuary marble, while another marked variety is a peculiar flesh colour dotted by nests of schorl. The bed of the Plym at Cadover yielded a large number of interesting petrological specimens to the researches of the members, and a brief halt there was well repaid.

From Cadover the route lay over Ringmore Down to the sequestered village of Sheepstor. On the road some abandoned china-clay pits, or "stopes," as they are locally called, were examined, to illustrate the kaolinised granite *in situ*. Crossing Ringmore, the altered rocks were seen to correspond in character with those at Shaugh; and a fine porphyritic elvan, hitherto unmapped, was discovered traversing the Devonians.

From the descent into the valley the grand old hill of Sheepstor and its "clatter"—a confused stretch of granite blocks which tells the tale of long ages of atmospheric waste—were seen to the best advantage, under the most brilliant effects of light and shade, and Dousland Barn was reached, after an exhilarating and in no way tiring walk.

FRIDAY.—This day was set apart for a visit to the volcanic centre of Brent Tor, Lydford being selected as the outward railway station and Mary Tavy as the homeward. A mile from Lydford Junction is one of the most remarkable features of Devonian

scenery, the picturesque Gorge, through which the Lyd brawls its way. The Gorge is within the grounds of Mr. Daniel Radford, who invited the Association to pay it a visit. On leaving the train, therefore, the party were conducted direct to Lydford Bridge, where they were admitted to the depths of this famous recess. Regarding this historic cleft as a fault fissure, or shake, worn into its present configuration by the action of the river, the Director showed that it did not stand alone, but was part of a network of ravines by which Lydford was so hemmed in that it could be approached from its own level on the moorland at one point only. The party were enthusiastic in their admiration of the Gorge, which was pronounced unsurpassed in its way as an example of erosive action, and the President (Dr. Hicks), accepting the Director's view of the initiation of the fissure, pointed out that its present configuration was due to the cross-jointing of the rocks.

Mr. Radford having been thanked for his kindness the start for Brent Tor was made, with a halt for refreshments immediately before commencing the stiff up-hill pull of nearly three miles from the railway level to the quaint church-crowned peak. Time had not, however, been wasted, for traces of organic remains had at last been found in the slates of the neighbourhood, and some evidence afforded that the rocks whence the Tor rises were not Carboniferous. The stone heaps of the roadside afforded some very good specimens of porcellanite, from quarries at the junction with the slates of the gabbro and allied rocks which form a belt by Smear Down, White Tor, and Cocks Tor.

Brent Tor has attracted notice from the very earliest dawn of geological science. Its peculiar peak, which, in ancient times, caused it to be selected as the site of its odd little church, and which has connected its history with myth and legend, has always given it a character of its own among Devonian heights. Sir Henry De la Beche was the first observer to form an unequivocal opinion as to its volcanic origin, for in his report he remarks :— "The idea that in the vicinity of Brent Tor a volcano had been in action, producing effects similar to those produced by active volcanoes from a similarity of causes, forcibly presents itself. That this volcano ejected ashes, which, falling into adjacent water, became interstratified with the mud, silt, and sand there depositing, seems probable. That greenstones and other solid trappean rocks constituted the lavas of that period and locality seems also a reasonable hypothesis. Upon the whole, there seems as good

evidence as could be expected, that to the north and north-west of Tavistock, ash, cinders, and liquid melted rocks were ejected, and became intermingled with mud, silt and sand, during this geological epoch, corresponding with the phenomena exhibited in connection with volcanoes of the present day."

One of the Memoirs of the Geological Survey is devoted to the "Eruptive Rocks of Brent Tor and its Neighbourhood." In this work Rutley took up the record of this volcano from the petrological side, and came to some very important conclusions. Sections were cut of all the leading varieties of rock and examined microscopically, the result being their identification as distinctly volcanic—pumice breccia, rhyolotic breccia, devitrified rhyolite, scoriaceous lava, decomposed basalt lava, pitchstone, and various forms of basalt in different stages of alteration. Rutley likewise examined the eruptive rocks of the district generally, and identified amphibolite bordering the granite of Brazen Tor, gabbro at White Tor, Smear Ridge, and Cocks Tor, schistose ash at Kilworthy, Hurdwick, and Milton Abbot, amygdaloidal ash (schalstein) at Churlhanger, and decomposed greenstone at Greston Bridge.

This monograph, however, does not contain Rutley's last published views as to the stratigraphical relations of the Brent Tor volcanic series. These are to be found in Quart. Journ. Geol. Soc., vol. xxxvi., 1880, p. 285. Here he points out the downthrow of the existing portion of the old volcano between two faults; that by far the greater portion of the cone has been long since removed by denudation; and that a considerable portion of the downcast must also have disappeared, leaving what is by comparison a mere mole-hill. The most important suggestions in this paper, however, are based on lithological similarity between Brent Tor rocks and schistose lavas and ashes of the Saltash district. These, he suggests, may belong to the same series, from which it follows either that the Saltash rocks are wrongly classed as Devonian, or the rocks around Brent Tor as Carboniferous; but there seems no doubt whatever that the Saltash rocks are Devonian; and the Director, in explaining these points, stated that any argument based upon the volcanic rocks of the Saltash area must apply also to those of the Plymouth district, into and through which the trappean bands of the Saltash area continue.

The Tor having supplied the wallets of the collectors with characteristic examples of its various rocks, it was descended with regret, and the road taken across bleak Black Down—where bands

of grit, interstratified with the slates, were detected by the President—to Wheal Friendship copper mine. The character of mining operations was here explained in such detail as time allowed, and a hunt in the "burrows" resulted in the discovery and annexation of some interesting mineral specimens. Among the rarer species was allophane; and a beautifully crystallized mineral, lining some cavities in a block of quartz, which at first rather puzzled the mineralogists, but was at length unanimously pronounced by them celestine. The visit to the mine brought the work of the day to a close.

Saturday.—On this day the excursion was brought to a close with a visit to the great china clay works at Lee Moor, near Plymouth, on the invitation of Mr. W. L. Martin.

The decomposed felspar which, when washed, constitutes the china clay of commerce, is worked at Lee Moor in a huge excavation, over 120 feet in depth, scarring the face of the hill for a considerable distance. Originally this pit was worked very shallow, and the water carrying the clay washed down from its sides to the depositing pits had to be pumped up. By driving an "adit" level from a lower point in the face of the hill, a distance of about half a mile, the depth to which the pit can be worked by gravitation has been so increased that the Lee Moor works are now the most extensive in the country. This adit, although worked on continuously night and day by three gangs (locally "cores") of men, took nine years to execute. Some of it was through exceedingly hard ground; some (and this gave the most trouble) through very loose ground. For a considerable distance it followed the line of a "flookan" or cross-course, which extends from end to end of the pit, and seems now as if it had reached a termination—if so, a very remarkable fact. In the course of driving the level several interesting minerals were found, and Mr. Martin thoughtfully had a series of these arranged for the inspection of his visitors. They included beautiful specimens of opal and jasper, an example of torbanite, and magnificent crystals and stones of tin, found at the intersections of some lodes and the cross-course. Although there are several lodes in the sett, the quantity of tin they contain is so small that Mr. Martin was perfectly astonished at the amount of work the old tinners must have done on that very spot, for what must have been very meagre results. The inspection of the pit section proved a matter of great interest, not only from the illustration of the way in which the clay was wrought by the operation of judiciously directed streams of

water down the faces of the stopes, but from a scientific point of view. The various lodes were clearly seen traversing the faces of the huge excavation, with the course of the flookan, and its effect in "heaving" the lodes. One lode had been carried some distance along with the flookan before it started on its own course again. Mr. Martin also showed the position of the best runs of clay and their peculiar relation to the lodes and cross-course. From the pit the party were conducted to a spot where the junction of the granite and the slate was to be distinctly seen. The rain was descending so heavily when the junction was reached that prudence forbade any lengthy or detailed examination, but the President was able to satisfy himself of its essential correspondence with the junctions traced on the previous Thursday—an important factor in any generalisation—though there are variations in the character of the changes at the junction itself, and the adjacent slates are more massive and ferruginous, and less andalusitic than at Shaugh. Some specimens of a very handsome black and white rock, picked up *en route*, have since turned out to be a variety of Luxullianite, with white instead of pink felspar; the first record of the occurrence of this rock in Devon.

The next point visited was the mouth of the adit, where the milk-white torrent comes rushing forth charged with the clay from the stopes, running at such a rate that it brings along stones of considerable size. Its course is soon checked, however, by a great gridiron of mica "strips," a series of narrow channels, in which the coarse material carried settles down, with a six-fold division. Thence it flows on peacefully enough, leaving behind the mica which had been in suspension, into the depositing pits, which form a double tier immediately above the collecting tanks. The latter again communicate with the "drys" where the water is driven off from the clay—by this time a thick pasty mass—by the agency of flues passing under the shallow tiled pans into which it has been allowed to run. When sufficiently dry, as Mr. Martin explained, it is cut into cubes, and piled under sheds, or barrelled, preparatory to being loaded into trucks which convey it along Messrs. Martins' private tramroad to their quays at Laira Bridge. All the stages in the production of the clay were followed and explained; and Mr. Martin showed also the range of kilns (which there was no time to visit) in which the sandy refuse, or what used to be considered as such, is made into admirable fire-bricks and tiles.

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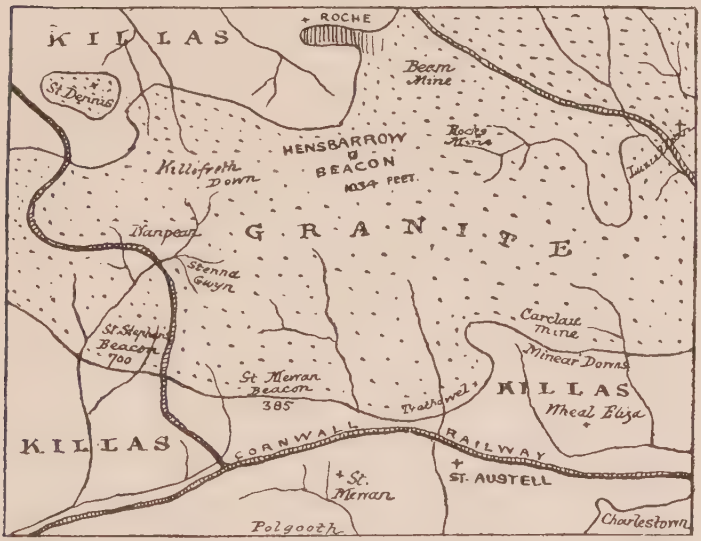
[For the literature of Kent's Cavern, see W. Pengelly, Trans. Devon. Assoc., vol. xvi. p. 189. These Transactions contain many Papers on the Geology of the District.]

CORNWALL.

[In August, 1887, there was an excursion to *Cornwall*, the Directors being F. W. Rudler, William Thomas, Sec. Mining Association and Institute of Cornwall, and A. K. Barnett. The districts around *Truro*, *Penzance*, and the *Lizard* were visited. See Proc., vol. x., No. 4, p. 196. (The maps relating to this excursion are here given.)]

FIG. 143.—MAP OF THE COUNTRY NORTH OF ST. AUSTELL.

Scale—Half an inch to one mile.



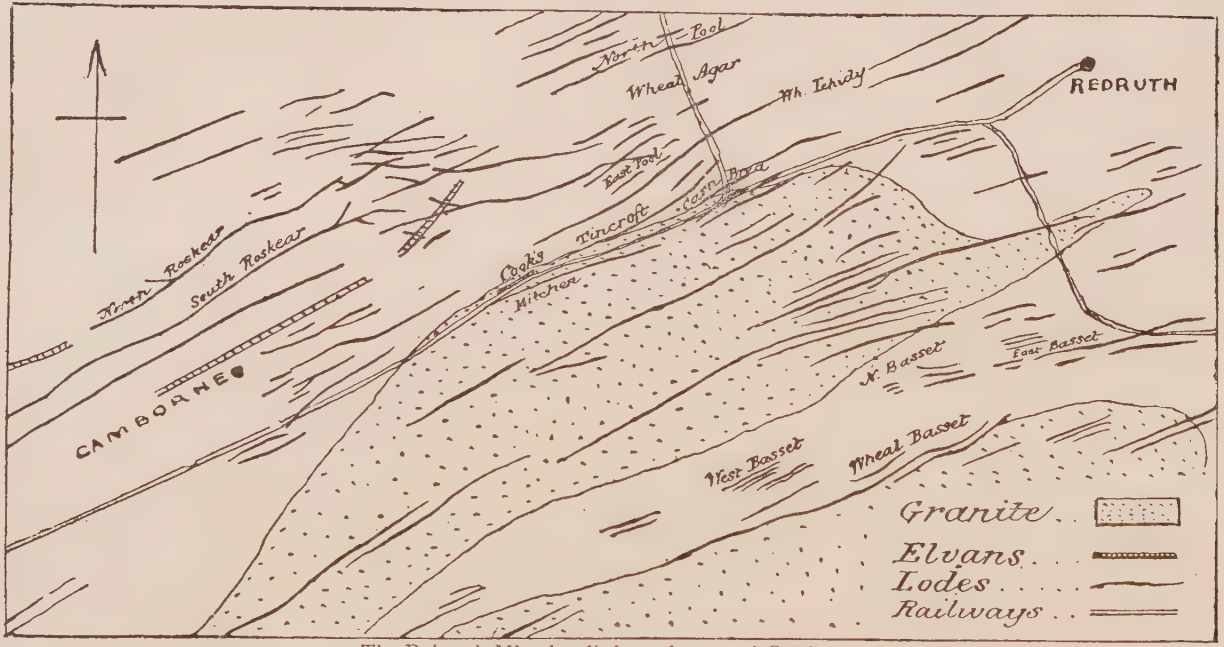
The Hensbarrow Granite is dotted, the Schorl-rock of Roche is indicated by vertical shading, and the Killas left blank.

FIG. 144.—SECTION OF PLIOCENE BEDS AT ST. ERTH, 1885

Vegetable Soil.
Head.
Yellow Sand.
"Growder."
Yellow Clay.
Blue Clay, with fossils.
Quartz pebbles.
Fine Quartzose Sand.
"Growder."
Elvan Dyke.

FIG. 145.—MAP OF THE COUNTRY BETWEEN REDRUTH AND CAMBORNE, SHOWING THE MINES NEAR CARN BREA.

Scale—One and half inch to one mile.



The Dolcoath Mine is a little to the east of Camborne.

FIG. 146.—MAP OF THE WESTERN EXTREMITY OF CORNWALL.

Scale—One inch to four miles.

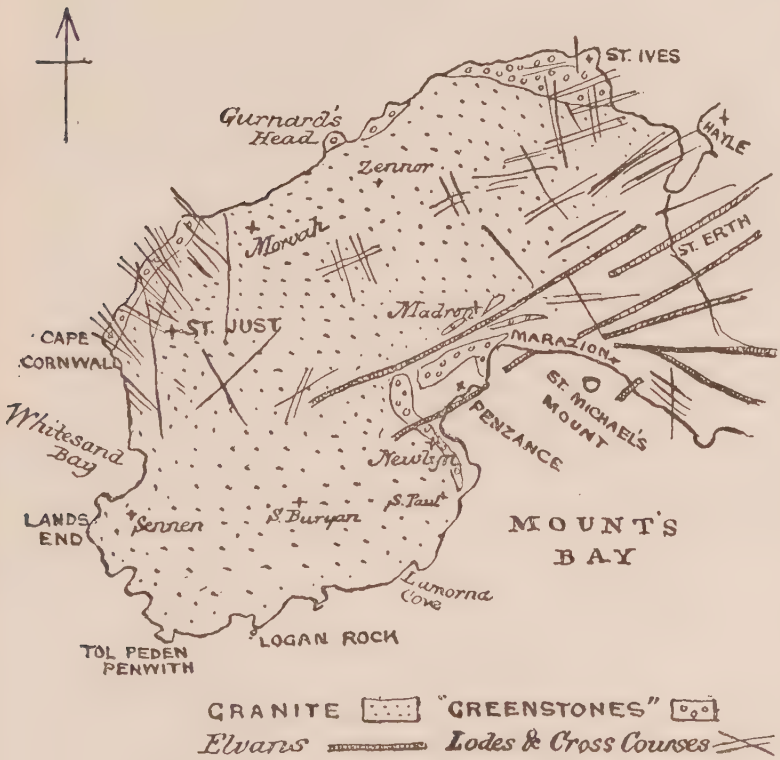
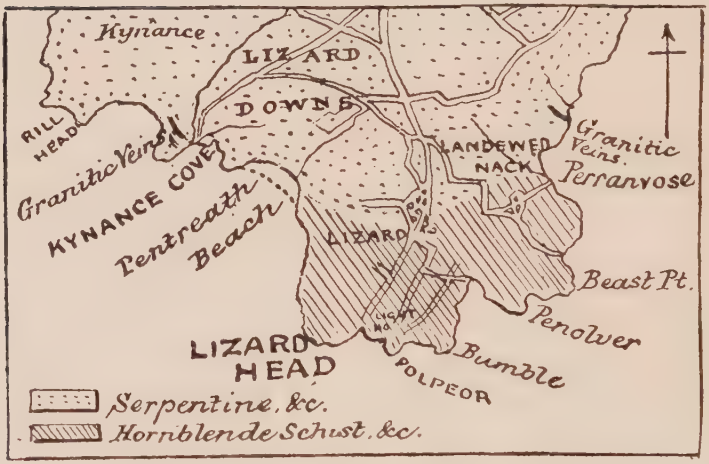


FIG. 147.—MAP OF THE LIZARD DISTRICT.

Scale—One inch to one mile.



A BREAK IS HERE MADE TO ALLOW OF BINDING IN PARTS CONVENIENT FOR THE POCKET.

WESTERN COUNTIES.

HEREFORD, WORCESTERSHIRE, SHROPSHIRE, AND STAFFORDSHIRE.

EXCURSION TO MALVERN.

JULY 21ST, 1873, AND FIVE FOLLOWING DAYS.

Directors—Dr. R. B. GRINDROD, F.G.S., the Rev. W. S. SYMONDS, F.G.S., and the Rev. ROBERT DIXON, F.G.S.

(*Report by* J. LOGAN LOBLEY.)

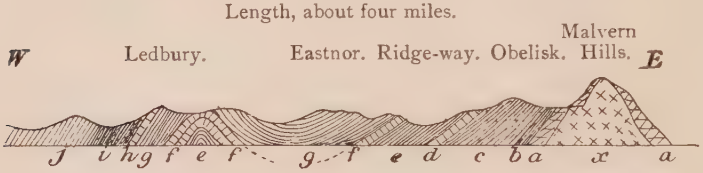
(*Proc. Vol.* iii. *p.* 269.)

THE members having assembled in the museum of Townshend House, Dr. Grindrod described his collection (now at Oxford), of the rocks, minerals, and fossils of the Malvern district.

The Director then conducted the party to the hills. The stones of which the road-side walls are built were, however, so attractive that slow progress was made, the party stopping to examine some more than usually fine specimen of syenite or epidote, which had been used by the builders, thus unconsciously making these walls answer the purpose of a museum of rock specimens. On the ascent of the hill splendid views were obtained, till the summit of the Worcestershire Beacon was reached. Thence the geologists surveyed the grand expanse of country around, extending from the Cambrian and Silurian country of the Longmynds and the Ludlow promontory to the Oolitic Cotteswold Hills. Dr. Grindrod pointed out the physical features of the surrounding country, and explained that the Malvern range, consisting of metamorphic syenitic rock, extended N. and S., with, on one side, Triassic strata stretching away to the east, while against the western slopes lay Upper Cambrian and

Upper Silurian Rocks, dipping to the west under the Old Red Sandstone, which forms the greater part of the county of Hereford.

FIG. 148.—SECTION FROM LEDBURY TO THE MALVERN HILLS.



j. Old Red Sandstone.
i. Shaly Sandstones.
h. Aymestry Limestone.
g. Lower Ludlow.
f. Wenlock Limestone.
e. Wenlock Shale.
d. Woolhope Limestone.
c. Upper Llandovery Sandstone and Conglomerate.
b. Hollybush Sandstone and Black Schist with Olenus.
x. Eruptive Rock, flanked by a Crystalline Felstone, Schist, and Gneiss Rocks.

LEDBURY AND EASTNOR.

The train was taken to Ledbury, where the Rev. W. S. Symonds, of Pendock, assumed the Directorship, and without delay led the way to the ascending path at the side of the railway. There, Mr. Symonds pointed out that Walls Hill, which was little more than a mile to the west, was capped by the "Cornstones" of the Old Red, the highest strata that would be seen during the day; and that the intermediate vale consisted of the Lower Old Red, the lowest bed of which they were then standing upon, since, in the adjoining tunnel mouth, the passage beds at the top of the Silurians were cut through. The thickness of the Old Red had been ascertained to be in Herefordshire 10,000 feet. In the lowest beds of the formation at this place *Cephalaspis Lyelli* and *Auchenaspis Salteri* had been found as in the corresponding beds near Ludlow. A little farther onwards an exposure of Aymestry Limestone was seen yielding *Lingula Lewisi*, but the principal characteristic species of the rock, the *Pentamerus Knighti*, is extremely rare at this place. Near the top of Dog Hill, a lane section of the Lower Ludlow Shales, exhibiting a decidedly nodular and concretionary structure, was seen, and here Mr. Symonds introduced to the party Henry Brooks, the fossil collector of Ledbury. The large quarries in the Wenlock Limestone, on the eastern side of the hill, were next visited, and *Stro-*

phomena depressa, *S. euglypha*, and fragments of *Phacops caudatus* were found. The Director explained the peculiarities of the Wenlock formation, and compared, or rather contrasted, the Wenlock Limestone with the Denbighshire Grits, which he had been lately examining near Llangollen. Continuing eastward past Eastnor, with its castle and magnificent park, traversing Lower Ludlow, Wenlock Limestone, and Wenlock Shale, and crossing a narrow band of Woolhope Limestone, members reached the lowest formation of the Upper Silurians, the Upper Llandovery. This formation, called also the May Hill Sandstone, lies unconformably on whatever rocks may be below. Sometimes it overlies one formation and sometimes another, and in this locality the whole series of the Lower Silurian is wanting, the Upper Llandovery being found reposing on, in one place, the Malvern syenitic rocks, and in another the "Black Shales" and trap rocks of Upper Cambrian age. Near Rowick is a roadside exposure of a mass of true igneous rock, one of the outworks, as it were, of the volcanic Ragged Stone Hill, which rears its summit a little to the east; at the foot of which, in the Valley of the White-leaved Oak, Mr. Symonds had kindly provided a luncheon. The fine neighbouring section exposing the inmost rock of the hill, with the "Holly-bush Sandstone," of Cambrian age, super-imposed, was then examined. The Ragged Stone Hill was, Mr. Symonds said, the roots of a volcano of probably great elevation, which, in the Cambrian period and while Cadir Idris was similarly active, poured forth lava and ejected ashes. These ancient volcanoes ceased to be active in the Llandeilo period, and previous to the activity of the great Snowdonian volcanoes which commenced in Caradoc times. Now, proceeding southward and skirting Chase End Hill, with Howler's Heath on the west, the members were brought to an exposure of the Permian Breccia, which lies against the Llandovery of Howler's Heath. A little further south a fine lane section of the Bunter rocks of the Trias, inclined at a considerable angle, reminded the party of the many and great changes and alterations of land and sea conditions through which the district had passed since the Malvern range first lifted its crest above the waters. The Rev. Reginald Hill had invited the party to visit him at his rectory of Bromesberrow; accordingly thither the geologists made their way. Leaving Bromesberrow Rectory, the road by Clencher's Mill, where Mammalian Drift was seen, and thence through Eastnor to Ledbury was taken, and the latter place reached in time for the train to Malvern.

Berrow, Pendock, and Tewkesbury.

A pleasant drive of ten miles through the Triassic plain at the base of the Malverns brought the party to Berrow Church. A visit was paid to the old church, which Mr. Symonds briefly described. The most noteworthy peculiarity of Berrow Church is the absence of a chancel arch, though it is not probable that this almost universal feature was always wanting. Leaving the church, the way was led to a quarry in the Upper Keuper Sandstone, which here abounds with plant remains as well as with fragments of *Ichthyodorulites*, or spines, of the fish *Lophodus*, together with the crustacean *Estheria minuta*, at one time thought to be a mollusc, and called *Posidonomya minuta*. The great number of remains of organisms seen here was a surprise to the geologists, who, knowing the general palæontological sterility of the Keuper, did not expect to find fossils in the "New Red Sandstone." Mr. Symonds drew the attention of his hearers to the fact that the previous day they had been examining Palæozoic rocks, while to-day they were on Mesozoic or Secondary strata, deposited since the dislocation which had produced the great fault running north and south along the eastern side of the Malverns, and extending to the Bristol Channel. But that all the Triassic land around them had been covered by the Liassic sea, and by Liassic strata, was attested by the Lower Lias outlier of Berrow Hill, not a mile from where they stood. James Plant, of Leicester, who has specially studied the Trias, described the Upper Keuper Sandstones, which are here quite similar to the beds of Leicestershire. They have a maximum thickness of from ninety to one hundred feet, and contain casts of worm tracks, ripple marks, and footprints of *Cheirotherium*, besides the fossils previously mentioned. Some small black spots found in these sandstones Plant thought might be particles of coal derived from the Coal measures, and not of direct vegetable origin as has been supposed. The Upper Keuper Sandstones, though not continuous, have been found over a large area, and they overlie the Keuper Marls above the Lower Keuper Sandstones or "Waterstones." At a very short distance from this highly interesting quarry the Upper Keuper variegated marls were seen cropping out. These dip towards Berrow Hill, the lower portion of which they form. Mr. Symonds pointed out an old house, Morton Court, at which the famous Cardinal Wolsey, when a young man, lived as chaplain, and then proceeded to relate the legend of the Ragged Stone Hill, whose

shadow is said to bring disaster and ruin upon whomsoever it may fall. That shadow had fallen on Wolsey when asleep in the garden, and hence his last hours were darkened by cruel misfortunes.

Turning from the Keuper with its facts, and the old house with its fables, Mr. Symonds led the way to Pendock Rectory. A visit was then paid to the ancient church of Pendock, which Mr. Parker considered to be of the time of Henry I., and the pointed chancel arch to be of the same age as the Norman pillars by which it was supported. The font was probably of the same period, but the tower of the church was of the reign of Edward III. or Richard II., and the woodwork of the seats of the time of Henry VII.

From Pendock Church an easterly route was pursued across the Triassic vale, and after a visit to Pull Court (Mr. Dowdeswell's), the sections of high-level gravel in the park of Pull Court were examined. In these gravels the tusk of a mammoth had been found, and here Mr. Symonds spoke of the period when the Straits of Malvern existed, and a yacht might have sailed from the mouth of the Severn to the mouth of the Dee. The party then rapidly proceeded through the richly timbered old park to the Tewkesbury road, by which the Severn with its fine section of Upper Keuper Marls was reached. Time did not permit of a detailed examination of the section, the principal features of which are, however, well seen from the bridge crossing the Severn at this point. The coloured bands of the Keuper Marls forming the cliff at the foot of which the Severn flows are very conspicuous and in striking contrast to the rich green of the alluvial meadows on the opposite side of the river. The members then returned by train to Malvern.

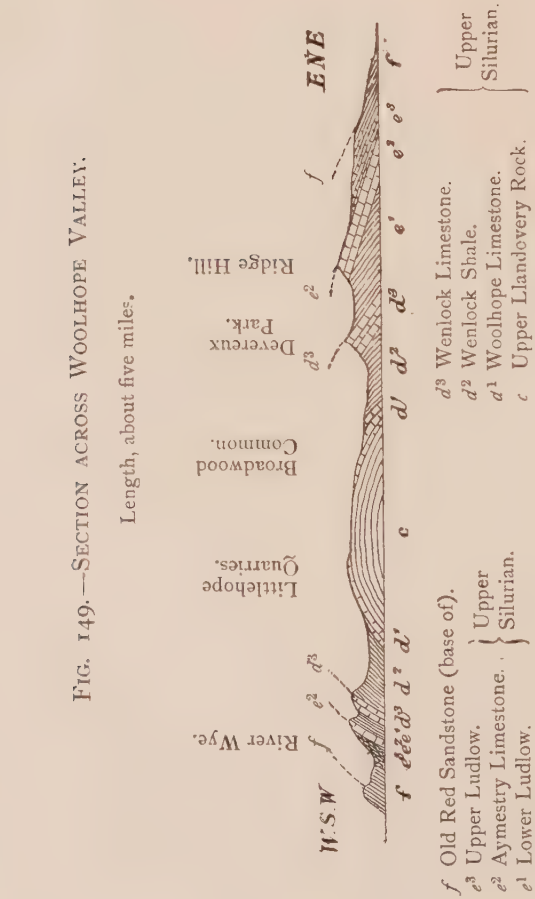
The Woolhope Valley.

The fourth day was devoted to the Woolhope Valley. The Rev. R. Dixon, the Director for the day, met the party at Stoke Edith Station. At the neighbouring Foley Arms, the room used by Murchison while exploring the Woolhope Valley was visited with interest, and then the road past Stoke Edith House was taken until Perton was reached. Here the first section was seen. The base of the Old Red is found resting on the passage beds representing the Tilestones, Downton Sandstones, and Bone bed, which overlie the true Upper Ludlow Shales, exposed to a depth of four or five feet, all conformable and dipping to the north away

from the centre of the Woolhope valley. The significance of this section will be subsequently apparent. Following the lane to the south, and ascending to higher ground, a fine exposure of Aymestry Limestone containing *Pentamerus galeatus* and *Cardiola interrupta* was met with. Passing onwards, and still ascending, they saw the Lower Ludlow Shales forming the banks of the lane, followed by the Aymestry Limestone. Crossing the high ground of Tower Hill the woods of Backbury Hill were entered, and presently, emerging from the trees, the geologists stood on the summit of the escarpment commanding the whole of the Woolhope Valley.

FIG. 149.—SECTION ACROSS WOOLHOPE VALLEY.

Length, about five miles.



All the rocks exposed in the valley are Upper Silurian, while the country outside the exterior rim is composed of Old Red Sandstone, which has been uptilted all around by the uplift of the underlying Silurian rocks. At the Perton section, previously mentioned, the edge of the encircling Old Red is seen with the uppermost Silurian strata beginning to appear. This section, therefore, gives a clue to the interpretation of the geology of the district. The outer and loftier rim of the valley is formed of the Aymestry Limestone, with an outside slope of Upper Ludlow Shales, and an inside slope of Lower Ludlow Shales. The inner of the two rims is composed of the Wenlock Limestone, with an inside slope of Wenlock Shale extending to a broad band of Woolhope Limestone which nearly encircles the centre dome of Upper Llandovery or May Hill Sandstone, the oldest formation seen. Thus it will be noted that, proceeding from the outer rim to the centre, older formations are met with in regular geological sequence, the hard limestones forming the ridges and the softer shales the intermediate valleys, with a central dome of siliceous rock. There is a prolongation of Ludlow rocks to the south-east, giving to the whole of this Silurian district an elongated pear-shaped form, and as on that side of the valley the strata dip at an angle of only 20°, while at the opposite or north-west side they have a dip of 50°, and even more, Mr. Dixon thought the upheaving force may have acted with less intensity at the south-east, and with increasing violence as it gradually approached the north-west. The symmetry of the valley is not perfect in consequence of a S.W. and N.E. fault occurring below Backbury Hill, which is suggestively parallel with a line connecting a boss of igneous rock at Lowes Hill and the uplifted Silurian Shucknell Hill. Mr. Dixon stated the summit of the Llandovery central dome covered by Haugh Wood to be 9,000 feet above the position it would have had if no upheaval had taken place. The elevation of Haugh Wood above sea-level is 570 feet, while the highest points of the outer rim at Ridge Hill, Seager Hill, and Marcle Hill are considerably higher.

After luncheon the steep Backbury Hill was descended, and passing through the dense plantations of Dormington the great Wenlock quarries of Dormington were reached and fine specimens of corals, including *Halysites catenularius* and *Favosites gothlandicus*, were found. Leaving the Dormington quarries the geologists made their way by the side of the Pentelow Brook, running between banks of Wenlock Shale, to a point at which is seen a remarkable

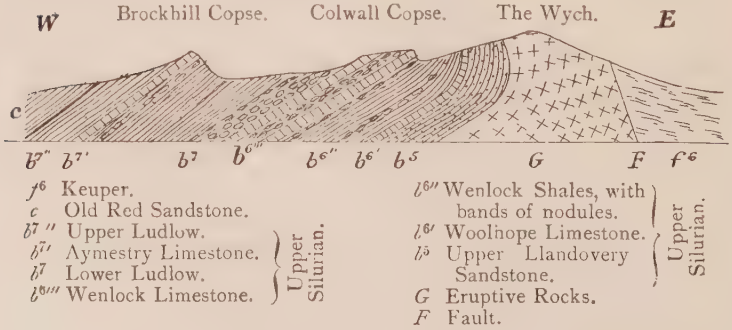
contortion of Woolhope strata, and thence by the Mordiford Road, past exposures of Llandovery rock to the gorge at the village of Mordiford. From this place the ascent of the central dome was made. A brief examination of the Woolhope Limestone of Scutterdine on the slope of the hill conclusively showed its distinction from the Wenlock Limestone; and at a little greater elevation the Upper Llandovery rock was found cropping out, and thus the centre of the valley of elevation and the geologically lowest rock of the district were reached. Descending the hill, Mordiford was again passed through, and emerging by the gorge from the Woolhope Valley the party entered the beautiful vale, where the Wye joins the "more lovely Lugg;" thence the road along the outer slope of the exterior rim and through the fertile vale of the Frome brought the geologists again to Stoke Edith station, where the train was taken for Malvern.

The Wych and Colwall.

The morning was spent in Dr. Grindrod's museum, and soon after midday Dr. Grindrod and his visitors sallied forth to examine the Wych and the western side of the hills. When the Wych Pass was reached rain fell heavily; nevertheless the geologists continued on their way and, after observing the Upper Llandovery resting against the central ridge of syenite, examined the Wenlock Limestone of the Colwall Copse quarries, which yielded some good specimens of the usual Wenlock species. The continued rain necessitated, however, a return to Great Malvern, where the interesting section at the back of the Belle Vue Hotel, showing Bunter Sandstone resting at a high angle against the Malvern syenite, occupied attention.

Fig. 150.—Section across the Wych.

Length, about one mile.



f^6 Keuper.
c Old Red Sandstone.
$b^{7''}$ Upper Ludlow.
$b^{7'}$ Aymestry Limestone.
b^7 Lower Ludlow.
$b^{6'''}$ Wenlock Limestone.
} Upper Silurian.

$b^{6''}$ Wenlock Shales, with bands of nodules.
$b^{6'}$ Woolhope Limestone.
b^5 Upper Llandovery Sandstone.
} Upper Silurian.
G Eruptive Rocks.
F Fault.

The Southern Malverns.

The last day.—The Rev. J. A. Panter, hon. sec. to the Malvern College Natural History Society, met the party in the museum attached to the college, which contains a choice collection of the fossils of the district. From the college, carriages were taken by way of Malvern Wells to the Herefordshire Beacon. The hill was ascended, and standing on the ancient British camp which crowns the summit, the visitors surveyed the hilly and richly-wooded country to the north and west, and then traversed the ridge to the south, passing "The Hermit's Cave," and turning westwards at the head of the beautiful vale opening to Eastnor Park. Soon the Upper Llandovery rock was seen in a lane section, and speedily *Lingula crumena*, *L. parallela*, and *Ctenodonta Eastnori* were found. With the Obelisk of Eastnor Park on the right hand, the path along the western side of Midsummer Hill was followed until the volcanic hill of the Ragged Stone was gained, when the section near the White-leaved Oak Valley was revisited, and the "Holly-bush Sandstone," the probable equivalent of the Lingula Flags, closely examined. This is the lowest and oldest unaltered rock of the district, and contains worm tracks and fucoids, several specimens of which were soon found. Descending the hill a field road was taken, when presently the darkened colour of the soil indicated the proximity of the "Black Shales," the geological position of which has been a subject of dispute. Four species of trilobites—*Olenus humilis*, *O. bisulcatus*, *O. scarabæoides* and *Agnostus pisiformis*—have been found in these shales, which have been by different authors correlated with the Llandeilo and with the Lingula Flags.

EXCURSION TO LEDBURY.

Monday, July 21st, 1879, and Five Following Days.

Directors—G. H. Piper, F.G.S. & Dr. Charles Callaway, F.G.S.

(*Proc. Vol.* vi. *p.* 233.)

Monday.—The party on arriving at Ledbury were met by Mr. G. H. Piper, and proceeded to examine the Ledbury railway tunnel, about 1,700 yards long. At the W. end the Old Red is seen on either side dipping at an angle of 75° south, and so continuing for about one hundred yards, when it passes into the

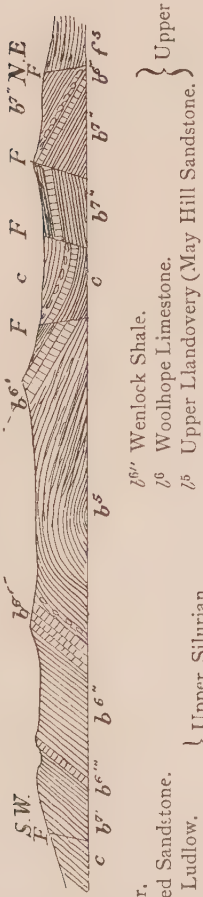
Downton Sandstone with passage beds between. In the Old Red *Cephalaspis*, *Pteraspis*, *Pterygotus*, and other characteristic fossils occur. Beyond the Downton Sandstone come the Upper Silurians, at first conformably, but afterwards much faulted and repeated as far as the east end of the tunnel, where they are covered with drift in which mammalian remains have been found. At the top of Ledbury Hill a good view was obtained of the physical features of the surrounding country.

Tuesday.—The members visited the district of May Hill. They first examined the exposures of the so-called Longmynd rocks, described by Murchison as occurring near the village of Huntley. These are dark grey, purplish, and greenish compact rocks, with a high dip, and are well exposed in a quarry on the roadside. The opinion of the members conversant with the Longmynd rocks in other areas was that they resembled those rocks in their mineral character and state of induration. They could not, however, after their previous examination of the Malvern Hills, subscribe to the following opinion expressed by Murchison in his later editions of "Siluria": "Seeing that this boss of old slaty rock is directly upon the southern extension of the ranges of the rocks forming the Malvern Hill, I would adduce this fact as a support to the conclusion I have already drawn—that the crystalline and schistose nucleus of those hills is of Cambrian age." This was expressed long after Holl's paper on the Malvern Hills was published (Quart. Journ. Geol. Soc., vol. xxi. p. 72), and contained, therefore, probably his latest view. The true reading, according to present knowledge, seems to be that these are the oldest Palæozoic rocks in the neighbourhood, and that the materials of which they are made were derived from the denudation of gneissic and chloritic rocks, similar to the pre-Cambrian rocks now exposed in the Malvern chain. In the hillside, about a quarter of a mile further towards May Hill, the conglomerates and sandstones of the May Hill series come on abruptly, and, probably, partly as the result of a fault. Higher up on the right hand side two large quarries occur, and here the rocks are beautifully exposed. The beds are at a low angle, and consist of alternations of sandstone and friable yellowish shale, the latter usually full of fossils. In ascending May Hill from this point several exposures of similar rocks were observed, but no further sections of any importance.

Wednesday.—By train to Knightwick station, where permission was freely accorded to examine the remarkable cutting in

the older rocks which commences at that point, and continues west for some miles. On the map of the Geological Survey, 55 S.E., it will be seen that a long "line of fault," which begins far down to the south on the right bank of the River Severn at Preston Passage, and runs between the Forest of Dean and the right bank of the river, extends as far north as Abberley, a distance of nearly forty miles. The line, as usual in very long faults, is not straight but curved considerably at several points; it forms a marked feature on the eastern side of the Malvern chain, faulting the older rocks against the Triassic beds. As this fault approaches Knightwick it throws off a small branch fault about three-quarters of a mile long to the N.W., which appears to end on the bank of the river Teme. About half-way on this branch fault another short fault strikes off to the N.E., about a quarter of a mile long. This short fault runs into the great forty-miles N. and S. fault. There appears to be another fault, making four, at this point, not laid down on the Survey map (being concealed by overlying drift beds), but opened out in the cutting at Knightwick station. These four faults have brought together, within a distance of less than six hundred yards, beds from the Upper Trias down to the Lower Silurian. The cutting appears to pass through the central portion of these faults. Of the entire section, certainly the most notable point is the letting down (or thrusting up) of

FIG 151.—SECTION ACROSS MAY HILL.



a mass of supposed Llandovery age, wedged between the base of the Permian and the base of the Old Red. It is very difficult to understand how this came about, the whole four faults (showing the various formations dipping at different angles) certainly could not have been produced at one operation. We should be inclined to consider that four different disturbances at least, at widely separated periods, had occurred, and this particular spot seems to have been a *focus* or crossing place. Of these independent disturbances, it may be noted that the Carboniferous rocks, of which none are actually *seen at any of the faults*, are well known to underlie the Permians of this district. This is seen at Oxenhall, near Newent, where coal seams are now being worked, some miles *south* of Knightwick, but again these same rocks are seen two miles *north* of Berrow Hill, where they crop out under the basement of the Permian. So there can be little doubt that at the third fault several thousands of feet of rock have disappeared.

Thursday.—After luncheon the party walked to the valley of the White-leaved Oak. On the western slope of Ragged Stone Hill the Black Shales were noticed, and some specimens of *Olenus* were collected. At the south end of the hill the so-called anticlinal was examined. It was found to be not a true anticlinal, but, as previously shown by Dr. Holl, simply a junction of the Hollybush Sandstone with the gneissic rocks of the central ridge, the sandstone dipping westward and the schists eastward. The Dictyonema Shales were not visited, but specimens kindly collected by Mr. Piper were exhibited in Ledbury, and Dr. Callaway identified in them *Macrocystella Mariæ*, Call., a cystid not before recognised out of Shropshire, forming an additional link connecting the Dictyonema beds with the Shineton Shales of the Wrekin.

Friday.—Investigation was mainly confined to the ancient rocks composing the central ridge of the Malverns. After a glance at the gneissic strata exposed in a quarry at the Wind's Point, where Dr. Callaway and Dr. Hicks gave a brief account of the structure of the chain, showing that it was made up of highly altered pre-Cambrian beds striking across the axis, with younger strata resting on the flanks on each side, the party were led to the "baked rocks" of Dr. Holl, which formed several spurs springing from the eastern side of the Herefordshire Beacon. These rocks were quite different from those of the main chain, and, as Dr. Callaway had recently discovered, closely resembled certain of the Shropshire pre-Cambrian strata at Lilleshall Hill, near Newport,

which he supposed were of Pebidian age. Prof. Bonney had also independently recognised a younger pre-Cambrian group in these rocks. They were seen to consist of felspathic material, generally very compact, with a horny fracture, and in places brecciated, but in the lower part (near the main axis) they were darker in colour and less indurated. Dr. Hicks agreed with Dr. Callaway's identification.

Starting from the Wych the party walked along the ridge to the Worcestershire Beacon. Dr. Callaway here pointed out the granitoid composition of the northern part of the Malvern chain, which confirmed, in his opinion, his view that these granitoid rocks were the equivalent of the Dimetian of St. Davids, Carnarvon and Anglesea. In places this granitoidite was very coarse-grained, and seemed to have originated in the metamorphism of a breccia. Dr. Hicks, also, was struck by the resemblance of these rocks to his Dimetian group. Associated with these more massive beds were bands of mica-schist, and of clearly foliated hornblendic gneiss, striking across the ridge. The Malvern "diorites" were also observed. These crystalline compounds of hornblende and felspar were so closely associated with hornblendic gneiss as to suggest that the "diorites" were simply the gneiss in a state of more complete alteration. On the western slope of the North Hill a band of decomposed greenstone, resembling the green bands in the Dimetian of St. Davids, was noticeable.

Saturday.—The party drove to the Woolhope district. As the time was short there was not much opportunity for inspecting the sections, but a good view was obtained of the physiography of this classical locality, with its concentric series of Upper Silurian limestone escarpments ranged round a centre anticlinal of Upper Llandovery rock.

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EXCURSION TO LUDLOW AND THE LONGMYNDS.

JULY 22ND TO 27TH, 1872.

Directors—Professor J. MORRIS, F.G.S., The Rev. J. D. LA TOUCHE, F.G.S., and ROBERT LIGHTBODY.

(*Proc. Vol.* iii. *p.* 124.)

AFTER the members had assembled in Ludlow Castle the Upper Ludlow rocks on the right bank of the Teme were examined, and Mr. Lightbody gave his reasons for considering the "Aymestry Limestone" to be represented at a point near the old bridge, although the species usually found in that rock, the *Pentamerus Knighti*, is not found here. The Upper Ludlow contains *Chonetes lata* in great abundance, and scarcely a fragment of the rock was picked up without this species being seen upon the surface. From the high ground by the river-side the valley of the Teme may be advantageously seen. The river here flows through a gorge in the Upper Ludlow rocks, with the castle and the town of Ludlow on the left bank, while the "Old Red" country extends beyond to the Clee Hills, the igneous summits of which commandingly rise to the east surrounded by the Coal measures. The well-known section in Ludford Lane, showing the "Bone bed," was then visited. This "Bone bed," or "gingerbread," as it is sometimes called from its appearance, is in places not more than a quarter of an inch thick and is found only after careful search. The fragments of the remains of fish which it contains were, until comparatively recently, the oldest fish remains known.

The following day (Tuesday) was devoted to an examination of sections of the Aymestry Limestone, Lower Ludlow, and Wenlock rocks, occurring in the course of a route of about twenty miles. The journey was performed by means of carriages, but abundant opportunity was given for collecting at the various exposures of the above-named richly fossiliferous rocks. Graptolites from the Lower Ludlow, near Leintwardine, were obtained in abundance, and fine specimens of the trilobite *Phacops longicaudatus* were found in the Wenlock Shale exposed in the bed of the Teme near Burrington, while *Pentamerus Knighti* was seen in great profusion in the Aymestry Limestone of Mocktree. Near the Comus Wood (so called from being the scene of Milton's "Comus") a most extensive view is obtained of the country to the south-east, the

Old Red Sandstone district of Herefordshire, with the Malverns in the distance. In the evening the members were entertained at a *soirée*, given by Mr. Humphrey Salway, of The Cliff, Ludlow.

During Wednesday the Upper Ludlow rocks in the valley of the Teme were further examined. The party proceeded to Downton, where the uppermost members of the series are seen at the Tin Mills section. From one point on the road to Downton the physiography of the district to the north of Ludlow is well seen, and here Professor Morris pointed out the principal features of the extensive landscape, and showed how entirely they were due to their geological structure, the hills and ridges being formed of hard limestone, and the valleys scooped out of softer strata which had not so successfully resisted denudation, while the Coal measures of the Clee Hills had been preserved by the old volcanic outbursts which had formed the central masses of hard "dhustone"* composing the summits and cores of these lofty hills.

On Thursday the party ascended the Longmynds at their southern extremity, where masses of quartzose conglomerate of Cambrian age protrude from the surface. The Rev. J. D. La Touche described the topography and the geology of the district seen from the elevated ground on which his hearers were assembled, and subsequently Dr. Hicks explained the order of succession of the Lower Silurian and Cambrian rocks of South Wales, which he had been re-examining during the previous fortnight. Some of these rocks Dr. Hicks considers have representatives in the beds of the Longmynds. The Llandovery conglomerates lying on the uptilted beds of the Cambrians, at an angle of 22° were well seen on the eastern slope of the hill, and the "Pentamerus Limestone," with its characteristic *Pentamerus oblongus*, was also found. The quarries of Caradoc rock in the Onny valley were then visited.

Friday was occupied by a journey in carriages to the mining district of Shelve and by an inspection of the very interesting hill-country between that place and Church Stretton. On the road to Shelve quarries in the Cambrian rocks at the south end of the Longmynds, and in the Llandovery beds near Marbury, occasioned stoppages. A visit was then paid to Linley Hall, where Mr. Jasper More invited the party to inspect his fine model of the South Shropshire mining district, also the famous pig of

*From the Gaelic "dhu" black; frequently corrupted locally into "Jewstone"!

lead of Roman age, with the name of the Emperor Hadrian upon it, found near Shelve, and specimens of the mineral products of the locality. The members were entertained at luncheon, and, leaving Linley Hall, proceeded by a long, narrow, and beautiful valley in the park terminating near the end of the Stiperstones. Outside Linley Park a mass of felspathic ash in Lower Llandeilo rocks is being quarried for road metal, and the Llandeilo beds, thus laid bare, were successfully searched for fossils. After a visit to the White Grit Mine the party commenced the ascent of the Stiperstones ridge, from the summit of which is seen a fine panorama of the Welsh mountains, with the old volcanic Corndon in the foreground, and Plinlimmon and Cader Idris in the extreme distance. The extraordinary masses of obtruding, hard, white quartzite rocks, called the Stiperstones, were objects of great interest and occasioned considerable discussion, and evidence was adduced to show that they were the equivalent of the Lingula Flags. The Longmynds range, running for several miles, bounds the view to the east, and this lofty ridge had now to be crossed. The intervening valley affords several sections, at one of which what Murchison considered to be the junction of the Cambrian and Silurian is visible. Near the summit of the Longmynds a very fine exposure of Cambrian conglomerates occurs, and further to the east the edges of the vertical green and purple shales and slates are seen beneath the feet as the mountain road is traversed. On the eastern side of the range the rocks are well exposed and the indenting ravines numerous and picturesque. Caer Caradoc stands boldly out at a little distance to the north-east, with the Wenlock and Aymestry Limestone ridges beyond, and bounding a valley of great beauty and extent, terminated northwards by the volcano-like cone of the Wrekin, at the base of which the Severn flows through a deep gorge.

The morning of the concluding day, Saturday, was given to an examination of the Upper Ludlow rocks, the bone bed and the "Downton Sandstone," in the neighbourhood of Norton Camp and Onibury, and the week's proceedings concluded with a visit to Stokesay Castle.

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[An excursion to *Dudley* was made on May 27th and 28th, 1863. See Proc. vol. i. p. 334. At Easter, 1890, the Pottery district of *N. Staffordshire* was visited, the headquarters being at *Stoke-upon-Trent* and at *Leek*, and the Directors Dr. Wheelton Hind, John Ward, T. Wardle, F. Barke, and A. Smith Woodward.]

EXCURSION TO THE NORTH WALES BORDER.

Monday, July 17th, and Five Following Days, 1876.

Directors—D. C. Davies, F.G.S., Professor J. Morris, F.G.S., and Dr. Henry Hicks, F.R.S.

(*Report by* D. C. Davies.)

(*Proc. Vol.* iv. *p.* 559.)

On Monday afternoon a short excursion was made to Cyrnybwch, two miles west of Oswestry, whence an extensive view was obtained of the border counties. Here Professor Morris pointed out the difference in the character of the landscape to the west from that to the east. To the west were the rugged rocks of Silurian age, broken up and sculptured into numerous mountain groups, and on the east there was the gently undulating plain of the New Red Sandstone; just to the west was a band of Carboniferous Limestone, which at this point appeared to be very thin, but this was owing to the highly inclined position of the strata. There was a difference in the manner in which the Silurian and Carboniferous strata were deposited; the former by mechanical segregation, the latter chiefly by living organisms, which built up bed after bed, so that the deposit was literally an accumulation of organic remains. Mr. Davies pointed out local illustrations of what Professor Morris remarked. Pointing westward, he said there were the Arenig or Lower Llandeilo beds, which would be seen running in ridges east and west. Upon these strata rested on either side a succession of greenstone, felspathic and porphyritic rocks, which were interstratified with slates, shales, and lime-

stones, all of which led up to the Bala Limestone, which was covered in its turn by shales and a limestone known as the Hirnant Limestone, all of which, with the overlying strata, would be seen during the week. Opposite the point where they stood the Carboniferous Limestone rested immediately upon the Llandeilo and Arenig strata, so that there was here a geological gap between the two formations of many thousand feet of strata. Northward, however, as they would see, the various intermediate beds, Llandeilo, Bala, Llandovery, Wenlock, Old Red Sandstone—all succeeded in their proper place, so that at a point ten miles to the north, the whole series was nearly complete.

FIG. 152.—SECTION TO ILLUSTRATE THE DRIFT OF THE N. WALES BORDER.

Coney Green Fields. Oswestry. Weston Fields.

1. Brick Clay. 2. Upper Boulder Clay. 3. Gravel, Sand and Boulders.

They would also observe the unconformability of the strata near the point on which they stood. The strike of the Silurian beds, as indicated by the mountainous ridges before them, was east and west, that of the Carboniferous Limestone, the Millstone Grit, and the Coal measures, north and south. Away in the distance to the south-east they would see the long ridges of the Longmynd, which were made up of Cambrian strata. Those beds dipped westward, and, following the various undulations of the strata, passed under their feet, and came up in the Merionethshire anticlinal, from Barmouth and Harlech northward, and further west still in the Cambrian rocks of Carnarvonshire. Nearer still than the Longmynd was the ridge of the Stiperstones, which, with its associated beds, they also saw in the Breidden range of hills, and this series was more largely developed in the hard ridges of greenstone porphyry, with their interstratified beds, which were spread out to the west. To the south they would see the southern termination of the belt of Coal measures which extended along the border to the estuary of the Dee. Of

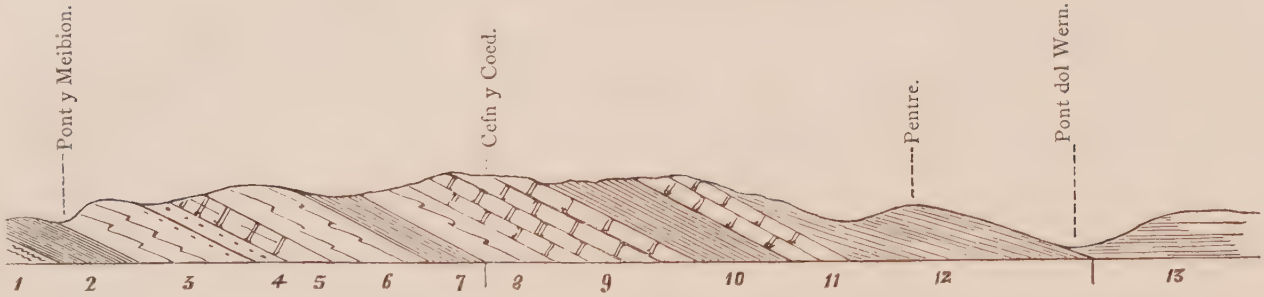
the Millstone Grit on which they stood he would have another opportunity of speaking, and he would conclude by pointing out the ridge of Grinshill and Hawkstone on the south, and that of Peckforton on the north. These two ridges were the outcrops of that basin or trough of Keuper Sandstones, in which lay the great salt deposits of this country. The party then collected fossils from the Millstone Grit, among which they found *Streptorhyncus crenistria*, *Athyris ambigua*, *Spirifera striata*, *Productus semireticulatus*, a large coral allied to *Clisiophyllum*, a smaller species resembling the *Petraia* of the older rocks, and a fragment or two of *Trilobites*, and then noticed the junction between the Carboniferous Limestone and the Millstone Grit, which is well shown on Offa's Dyke, after which they returned to Oswestry.

FIG. 153.—OSWESTRY RACECOURSE (DRIFT).

1. Brown adhesive sand with Scotch granite.
2. Layers of sand and pebbles.
3. Pebbles.
4. Brown sand.
5. Very fine light brown sand.

On Tuesday morning members assembled at Pontfaen, a romantic spot on the river Ceiriog, near Chirk, from which they proceeded by the Glyn Valley tramway to Pontdolwern. A walk of about a mile brought them to Nant Iorwith, where there is an old quarry in the lower beds of the Bala Limestone. A halt was made while Mr. Davies explained the geological structure of the locality. He said that two miles to the south of them a band of greenstone surmounted a thick mass of dark shaly and slaty rocks, in the upper part of which there were also frequently thin bands of metamorphic rock. This greenstone he took to be the base of the Llandeilo strata of the district, the beds below belonging, as he thought, to the Arenig group. Above this greenstone, and dipping north, or towards where they stood, there was a thick deposit of black shales, with occasional bands of hard rock. This was surmounted by a thick deposit of stratified porphyritic rocks as seen at Pontymeibion and Llechryddau. The beds of this group were very varied, and some were beautiful, consisting of

FIG. 154.—STRATA IN GLEN CEIRIOG.



Llandeilo.
1. Compact Greenstone.
2. Dark pyritous Shales.
3. Porphyritic Shales.
4. Sandstones and Shales.
5. Dark Limestone.
6. Massive Felstone and Ashy Beds.
7. Shales and Slaty beds.

Bala.
8. Ashy Beds.
9. Bala Limestone.
10. Fossiliferous Shales.
11. Hirnant Limestones.

12. Llandovery beds (very fossiliferous).
13. Wenlock Shale.

Horizontal scale, two inches to one mile.

NOTE.—The porphyritic beds, No. 3, are very remarkable and some of them beautifully stratified. The Limestone No. 5 is that which was originally described by Sedgwick as "the Dark Limestone of the river Deirew."

angular fragments of red felspar, cemented in green, cream-coloured, and white paste. This porphyritic group was overlaid by a thick mass of dark shales, which in their turn were capped by a band of felspathic rock, the upper bed of which was very pure, and was quarried in the neighbourhood for the manufacture of china. Above this felspathic band was a band of dark limestone not marked on the maps, which he took to be the equivalent in North Wales of the Llandeilo Limestone of the South. This limestone was rich in fossils. He thought it corresponded to the limestone at Craig y Glyn, eight miles to the S.W. on the other side of the anticlinal he spoke of yesterday. Then came more shales, followed by a thin ash bed, known as "The Bala Ash," which might fairly be taken as the boundary between the Llandeilo rocks below and the Bala or Caradoc group above. They could see this ash bed close to where they stood, and would observe that it did not lie far below the Bala Limestone. They would soon find how rich this limestone was in fossils. The lower beds, as they saw, were massive, but in a quarry higher up in the series, to be visited presently, the beds were much thinner and were interstratified with shales. In those higher beds the prevailing corals, *Halysites* and *Heliolites*, appeared in plenty. The limestone was about 300 feet thick, and was not nearly so fragmentary and inconstant as it had sometimes been represented to be. Above the Limestone lay some fossiliferous pale shales, and then came the Hirnant Limestone, so called because it was observed first in the valley of the Hirnant, near Bala. This limestone he took as the summit of the Bala group. Above it came the Llandovery beds, which lay before them to the north-east, and which were surmounted by the hills of Wenlock Shale on the other side of the valley. The Llandovery beds thickened greatly in their progress to the north-west towards Corwen, so that at this point they were present only in an attenuated form. The Wenlock beds would be visited another day.

Dr. Hicks then made some remarks concerning the mode of deposition of the groups of strata described. He said he would be glad to know whether the strata absent at this point belonged to the lower or upper beds of the Llandovery group, and whether the gap lay between the Llandovery beds and the Tarannon Shale, or between the latter and the Wenlock beds. It was also a question whether the Tarannon beds were most nearly allied to the Wenlock or to the Llandovery. He could hardly assent to the unconformability described, and

suggested that the absence of several of the beds might be due to a fault.

Mr. Davies, in reply, said that he had considered whether the absence of many of the Llandovery beds might be due to a fault, but he failed to see how that could account for the fact of the gradual thickening of the beds northward, and the disappearance one by one of the underlying beds southward, until, as pointed out yesterday, west of Cyrnybwch, the Carboniferous Limestone lay directly upon Lower Llandeilo or Arenig strata. It was the upper members of the Llandovery beds that were absent there, and northward they appeared one by one from underneath the Tarannon Shale. Though the gap at this point lay between the Tarannon Shale and the Llandovery beds, yet he regarded the former as being more allied to the latter group than to the Wenlock Shale.

Sections showing Structure and Form of Valleys on the North Wales Border. [Davies.]

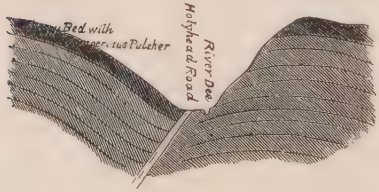
Fig. 155.—Valley of upheaval, Glen Ceiriog.

Llandeilo and Bala Beds.

Fig. 156.—Valley of erosion in perpendicular strata, Cwmgwynen.

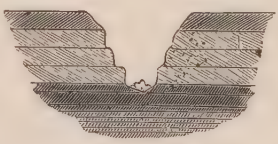
Bala Limestone.

Fig. 157.—Valley along course of Fault, Glyn-dyfr-dwy.



Wenlock Shale.

Fig. 158.—Valley of erosion in horizontal strata, Pentre Glyn Morlas.

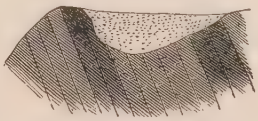


Upper Coal Measures.

FIG. 159.—Valley along escarpment due to erosion along line of junction between two formations, Craigforda.

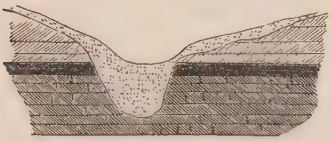
Carboniferous Limestone and Millstone Grit, capped by Coal Measures.

FIG. 160.—Blaen Rhiwarth Longitudinal Section.



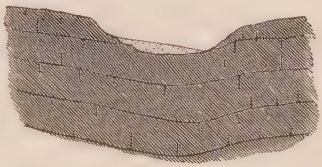
Bala Limestones and Shales.

FIG. 161.—Old valley filled with Drift, Blaen Rhiwarth, Berwyn Mountains.



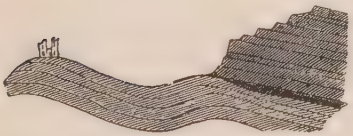
Bala Limestone and Shales.

FIG. 162.—Valley of depression supplemented by erosion, Porthywaen.



Carboniferous Limestone.

FIG. 163.—Llangollen—Dinas Bran and the Eglwyseg Rocks.



Wenlock Shales and Carboniferous Limestone, with thin parting of Old Red Sandstone.

FIG. 164.—Valley in trough made by two parallel E. and W. Faults, River Dee, below Wynnstay.

Coal Measures.

Professor Morris spoke of the importance of the questions they were discussing. The only way of arriving at a satisfactory solution of many geological problems was by careful local investigation, associated with a broad correlation of similar phenomena over a large area.

The search for fossils then began, and was rewarded by many specimens of *Lingula longissima*, *Orthis calligramma*, *O. elegantula*, *O. Actoniæ*, *O. porcata*, *Strophomena depressa*, *Theca*, *Bellerophon*, *Lituites*, *Asaphus Powisi*, *Phacops*, *Trinucleus*, and other well-known fossils of the Bala Limestone.

The party then ascended to Cefn-y-Coed quarry, where some good examples of *Halysites catenularis* were obtained. A scramble over the edges of the overlying shales led to the Hirnant Limestone, some of the beds of which were a mass of fragments of organic remains. A start was then made for the New Inn, Glyn Ceiriog, where luncheon had been provided by Mr. John Jones.

Afterwards most of the party walked up the valley to its junction with that of the Deirw, where a good view was obtained of the felspathic and porphyritic rocks which had been described in the morning.

On WEDNESDAY the first point of interest visited was a quarry in the Carboniferous Limestone, at Dolcoch, three miles south of Oswestry. From this a good view of the whole series of limestones could be seen. Mr. Davies said the party then stood within three miles of the southern termination of the band of Carboniferous Limestone which runs along the North Wales border. He described it as consisting in ascending order of, first, a series of pale-coloured beds, much quarried for fluxing stone; secondly, a series of thin grey beds which, in that neighbourhood, passed into a reddish impure limestone used for mending roads; and, thirdly, a succession of grey limestones and shales abounding in corals, *Productus*, *Spirifera*, and the usual fossils, and noted in this neighbourhood for occasional large specimens of *Orthoceratites* and *Nautilus*. The quarry they were in was in the middle portion of these upper beds, and he had no doubt many fossils would be found. Professor Morris described the characteristics of the genus Productus, the most abundant group of shells in the Limestone, and stated that Dr. Chas. Barrois, who was present, was much struck with the resemblance of the Limestone to that of Vesey, in Belgium. Among the fossils found were *Strophomena analoga*, *Productus latissimus*, *P. giganteus*, *P. Youngianus*, *Chonetes hardrensis*, *Streptorhynchus crenistria* with its variety *senilis*, *Athyris Roysi*, *Rhynchonella pugnus*, *R. pleurodon*, *Orthis resupinata*, *O. Michelini* with *Lithostrotion irregulare*, and other corals, also several specimens of Conchifera, not determined. The position of the corals and shells *in situ* in the beds was also noticed, showing how their remains constituted the greater part of some of the layers of limestone.

After luncheon, provided by Mr. Stanley Leighton, M.P., a visit was made to a quarry in the Millstone Grit, close by. After numerous specimens of *Productus semireticulatus* had been obtained

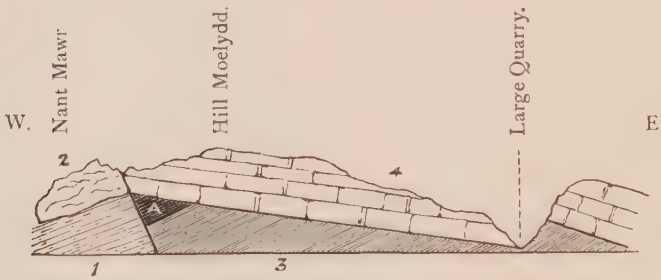
from one of the upper sandstone beds where they lay in shoals, Mr. Davies gave a brief description of the Millstone Grit of the district. He described it as about 300 feet thick. It consists of a series of red and yellow sandstones at the base. These are often coarse and pebbly in structure; but they contain numerous fossils, including the Permian shell *Schizodus*. In the middle portion there were some calcareous sandstones, which, in their progress northward, became decided limestones, and were quarried near Mold for agricultural lime. The upper portion, in which the quarry was situated, consisted of massive beds of white and buff-coloured sandstones, with coarse pebbly beds and thin clay and iron stones. It was from this quarry, and from the bed from which the shells had just been obtained, that a large *Orthoceratite*, about 6 ft. long, and 1 ft. 6 in. in diameter at the largest end, had been obtained. That specimen was now in the Derby Museum, Liverpool. He regarded the beds from the calcareous bands downwards to, and perhaps inclusive of, the uppermost Carboniferous Limestones and Shales, as the equivalent of the Yoredale series of the north of England. Above the middle limestones was the true Millstone Grit. Although the Coal measures came in just outside the quarry, these were not the highest beds of the formation. Those seen on Monday afternoon were higher, and the sandstones at Trevor, near Llangollen, were higher still. Associated with the shells in the quarry were stems of *Calamites*, and fragments of other Coal measure plants, which were the heralds of the more abundant flora of which the Coal beds were formed. He directed attention to the curious "pockets" which occurred in the solid sandstone on all sides of the quarry, and would like to hear Professor Morris's explanation of them.

Professor Morris said the material of the pockets was, he believed, made up of iron and manganese, mixed with loose sand. There was an absence in the pockets of the felspar, which was the cementing matrix of the sandstone. It had been observed that there was a tendency in minerals to segregate around a common base, and instanced some mines in Spain where the same tendency was observed among the metallic refuse.

The middle calcareous beds were then visited, at which point the party separated. One section made for some old quarries at Wern, where many corals were found. These included *Lithostrotion irregulare*, *L. junceum*, *L. minor*, *L. floriforme*, *L. Martini*, *L major*, *Phillipsastrea radiata*, and *P. tuberosa*. The other section went by the quarries at Treflach, where they found *Zaphrentis*

cylindrica, *Syringopora ramulosa*, *S. gemiculata*, and *Alveolites septosa*, in addition to some of the corals enumerated above. A large party proceeded to the hill Moelydd, from which a grand

FIG. 165.—ILLUSTRATIVE OF THE RELATIVE POSITION OF THE CARBONIFEROUS LIMESTONE TO THE LLANDEILO AND BALA BEDS AT MOELYDD, FIVE MILES S.W. OF OSWESTRY, AND SHOWING THE ABSENCE OF ALL THE INTERVENING STRATA, AS SEEN IN FIG. 166.



Llandeilo.
1. Shales.
2. Felspathic Trap and Greenstone, with crystals of Sulphate of Iron.
3. Bala Schists, with a dark-coloured, very fossiliferous bed, A, in their upper portion.
4. Carboniferous Limestone.

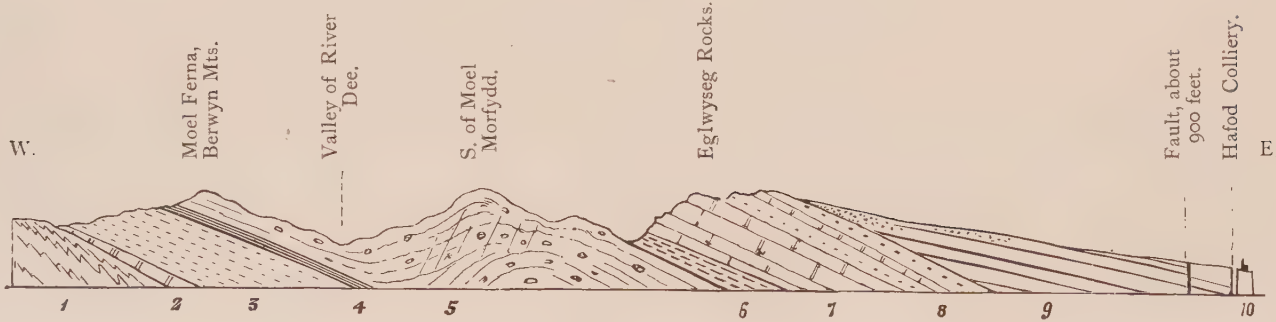
Length of Section, 1¼ miles.

panoramic view of the mountains of North Wales, as well as of the Shropshire and Cheshire plains, was obtained. Professor Morris gave an address on the geographical features of the landscape, in which he pointed out the difference between the conical Silurian hills and the ridges of Limestone, whose escarpments were so well seen from where they stood. He noticed how the edges of the limestone beds abutted below their feet against the greenstone boss which forms the western face of the hill, whose true place was thousands of feet below them. He also pointed out how the beautiful crystals of sulphide of iron the rock contained indicated the presence of vegetation in the early sea in which it was formed. In the comparative level of the plains to the east they saw the greater freedom from disturbances which characterised the newer deposits.

On THURSDAY the party proceeded by rail to Llanderfel station. After refreshments, provided by Mr. Ruddy, an inspection of an interesting series of fossils collected by him was made, and a

FIG. 166.—SHOWING SEQUENCE OF THE GEOLOGICAL FORMATIONS BETWEEN A POINT EAST OF LLANDEILO AND HAFOD-Y-BWCH COLLIERY, RHUABON.

Horizontal Scale, $\frac{3}{8}$ of an inch to 1 mile.



1. Llandeilo beds, with Greenstones and Porphyries.
2. Place of the Bala Limestones, Shales, and Hirnant Limestones.
3. Llandovery beds, very fossiliferous.
4. Tarannon Shale.
5. Wenlock Shale, with a capping of Ludlow beds in places.
6. Old Red Sandstones.
7. Carboniferous Limestone.
8. Yoredale Rocks, and Millstone Grit.
9. Coal measures.
10. Permian.

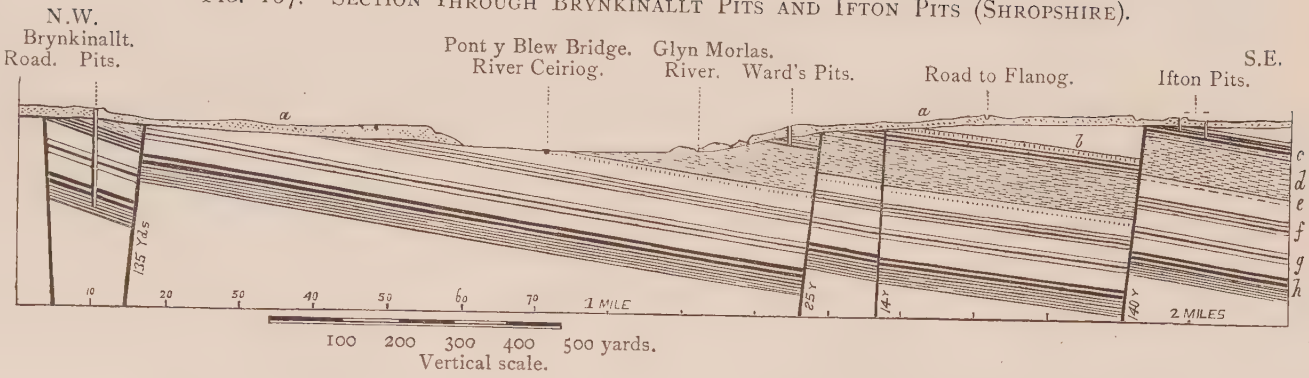
NOTE.—The Wenlock beds are for the most part unfossiliferous. The Upper Limestones of the Eglwyseg Rocks are very rich in corals.

quarry in the Wenlock Shale at Bryn Sylwrn visited. Here *Diplograpsus pristis* and *Retiolites Geinitzianus* were found, also beautifully preserved specimens of the internal tubes of *Orthoceras primævum* with *Athyris marginalis*. Professor M'Kenny Hughes pointed out the striation of the rock surface, and the difference between cleavage, joints, and bedding. He showed how the beds of the quarry rested upon the Tarannon Shale close by, and how, with their overlying grits and uppermost slates, they dipped under the Berwyns, and rose again on the other side.

The ascent of the Berwyn Mountains was then made. Professor Peters, of Bala, pointed out objects of local interest, and halts were made to admire the scenery, which included most of the Welsh mountain ranges. Before descending to Llangynog a visit was paid to a mine worked in the Phosphate bed of the Bala Limestone. Mr. Davies described the position of this bed as being at the top of the Bala Limestone, which there was about 300 feet thick. The bed varied from nine to eighteen inches in thickness, it was nodular in form, and some of the nodules still preserved their organic structure. The question had been raised: Was the bed deposited pure and simple from the phosphoric acid diffused through the water, or was it first taken up into organic life and then deposited? The latter, he thought, was the true theory where the mineral occurred, as it did in Wales, in widespread beds. The party went into the mine, saw the bed, and followed it through all the workings. *Orthis spiriferoides* and other fossils were obtained from one of the beds of the Bala Limestone, and then the party made the best of their way down the valley of the Rhiwarth to the New Inn, to Llangynog, where luncheon had been provided by Mr. John Dovaston. The members then assembled under the Rhiwarth slate quarry, where, by the kindness of Mr. George Savin, and Mr. Roberts, the manager, much interesting information was obtained.

By the aid of a large section Mr. Davies explained the structure of the Berwyn Hills, and the country generally lying between Llanfyllin and Dinas Mawddwy, and he pointed out the correspondence stratigraphically of the Llangynog slate rocks with those of the Ffestiniog district. Professor Hughes described the way in which the mountains and valleys had been sculptured into their present form by the streams wearing back the ends of the cwms or valleys. Dr. Hicks described the strata lying below those given in Mr. Davies' section, the Menevian and

FIG. 167.—SECTION THROUGH BRYNKINALLT PITS AND IFTON PITS (SHROPSHIRE).



a. Boulder Clay and Gravel.
b. Coed-yr-allt Rock.
c. Ifton Coal.
d. Red Marls and Rock.
e. Porous greenish Sandstone.
f. Newbridge Shales and Coals.
g. Dirty Coal.
h. Yard and half, Main and other Coal seams.

Datum line 1645, 23 feet below stone in parapet of Pont-y-Blew Bridge.

Upper Cambrian groups, with the many remains of former life which had latterly been discovered in them, and after a few concluding words from Professor Morris the party started for Oswestry, stopping by the way to notice the curved strata near the bowling green at Llangedwyn. Oswestry was reached at ten o'clock.

On Friday morning the districts of Trevor and Llangollen were visited. The first point of interest was the brick-works of Mr. C. Mason, which lie on the junction of the Millstone Grit with the Coal measures. The various beds were described, and their relation to similar beds in Lancashire and Yorkshire was pointed out. The party was then led by Mr. Mason to a new railway cutting, in which a good section of the Chwarele coal and clay was exposed; some interesting plant remains were observed on the sandstones. The Garth limestone quarries were next reached, and a halt made, in which there was a successful search for fossils, several groups of which were described by Professor Morris. A walk brought the party to the bold ridge of the Eglwyseg rocks, near Tan-y-Castell, where many good specimens of the fossil shell *Productus llangollensis* were obtained. Some of the party prolonged their walk to Valle Crucis Abbey, and the rest walked to Llangollen. Mr. and Mrs. James Barnes had previously invited the members of the Association and their friends to dine at Brookside House on this evening.

References.

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New Ordnance Survey. Sheets 121, 122, 137. 1*s.* each.

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D. C. Davies, On some of the Causes which have helped to shape the land on the North Wales border. *Ibid.* vol. iv. p. 340.

D. C. Davies, On the Drift of the North Wales border. *Ibid.*, vol. iv., p. 423.

D. C. Davies, On the Overlapping of several Geological Formations on the North Wales border. *Ibid.*, vol. ii. p. 299.

EXCURSION TO BANGOR, SNOWDON, HOLYHEAD, &c.

On July 23rd, 1883, and Five Following Days.

Directors—Dr. H. Hicks, F.R.S., and Prof. T. McKenny Hughes, F.R.S.

(*Report by* T. McK. Hughes.)

(*Proc. Vol.* viii. *p.* 195.)

This excursion had for its principal object the investigation of the mass of Archæan rocks in the neighbourhood of Bangor and Carnarvon and its relations to the overlying Cambrian.

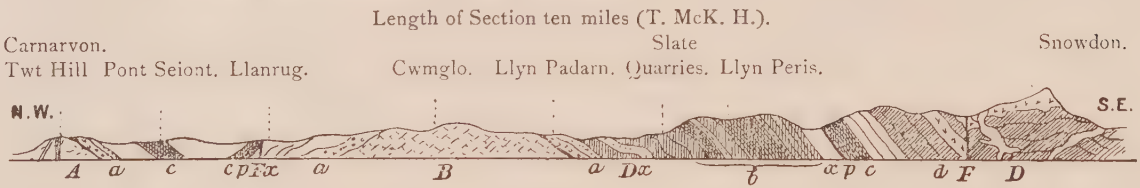
The sections were generally worked in the descending order of succession of the strata, and the same plan will be adopted in this report, the aim of which will be to place on record the facts observed, so that members who joined the party can most easily refer hereafter to the sections seen by themselves and the localities visited, and follow most readily any interpretations placed upon them in future discussions.

It was of course of the first importance to settle what were the basement beds of the Cambrian, and how they varied in closely adjoining areas; for it was thought that if by following the beds down from known and often fossiliferous rocks we could establish any tolerably constant horizons, then, whatever difficulties might arise from the intercalation of other rocks here and there, we should at any rate generally know when we had got to the bottom of the series.

The course of our wanderings took us up into much higher beds of the Cambrian and even over a considerable thickness of Carboniferous rocks, and these often furnished by their local variations important illustrations of many points of difficulty in the older formations.

We counted down all the beds from the top of Snowdon, where we were on Bala Shale with *Orthis flabellulum*, of which we found plenty of specimens in place close to the little inn on the summit. In descending we crossed alternations of volcanic agglomerates, ashes and shales as far down as the Half-way House. A strong volcanic breccia forms a conspicuous feature just in front of the house, and was especially interesting to our party as it closely resembled some of the Archæan volcanic rocks we had passed over near Bangor. Below this the volcanic material soon

FIG. 168.—DIAGRAM SECTION SHOWING THE SEQUENCE OF ROCKS FROM CARNARVON TO SNOWDON.



Archæan { A. Carnarvon Group (Dimetian). B. Dinorwig Group.

a Conglomerate and Sandstone. Basement bed of Cambrian.

b Lower and Middle portions of Cambrian not subdivided, but probably including Harlech, Menevian, Lingula flags, and Tremadoc beds.

c Arenig.

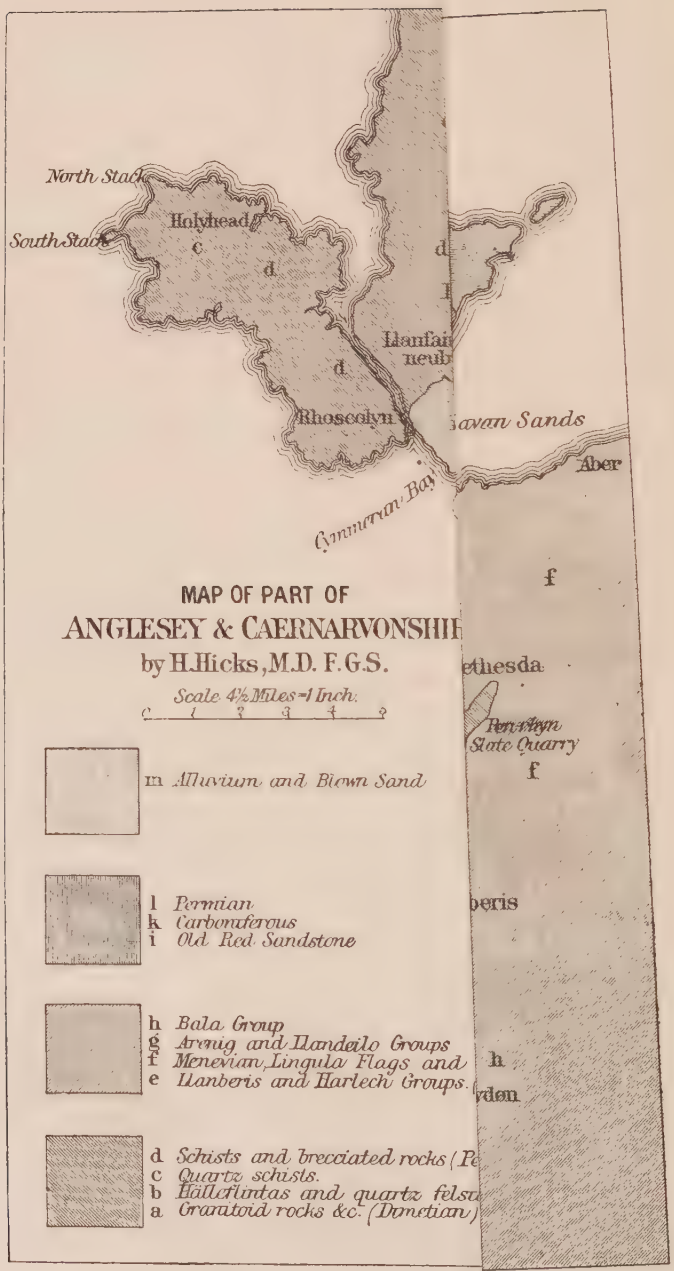
p Pisolitic iron-ore.

d Bala group with subordinate volcanic beds.

F Faults.

x Broken ground.

D Dykes.


North Stack
South Stack
Holyhead
c
d
d
d
Llanfair
neub
Rhoscolyn
avan Sands
Aber
Cymmeran Bay
f
ethesda
Penrhyn
State Quarry
f
MAP OF PART OF
ANGLESEY & CAERNARVONSHIR
by H. Hicks, M.D. F.G.S.
Scale 4½ Miles = 1 Inch.
0 1 2 3 4 5
m Alluvium and Blown Sand
l Permian
k Carboniferous
i Old Red Sandstone
beris
h Bala Group
g Arenig and Llandeilo Groups
f Menevian, Lingula Flags and
e Llanberis and Harlech Groups.
h
ydon
d Schists and brecciated rocks (Pe
c Quartz schists.
b Hälleflintas and quartz felsu
a Granitoid rocks &c. (Donetian)

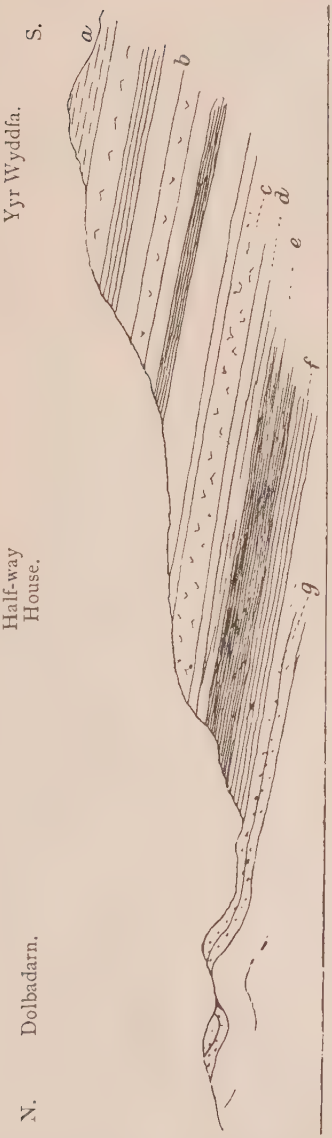


FIG. 169.—DIAGRAM SECTION. SNOWDON TO DOLBADARN.

became quite subordinate, and we found only black shales passing down into banded, flaggy beds which rested on a thick bed of tough quartz grit. In the black shales we found graptolites, perhaps *Climacograptus cælatus*, but the specimens were not sufficiently well preserved for us to feel sure on this point. We had now reached the disturbed ground near the foot of the mountain, and the only point we made out clearly was that the grit rolled over and over along the high bosses which form the summit of the ridge flanking Llyn Peris at its N.W. end. The details of the lower ground have not yet been thoroughly worked out by any one; but we had above us an unbroken succession, from fossiliferous Bala, across other fossiliferous beds, suspected to be Arenig, down to the well-marked grit in front of us, as shown in Fig. 169.

In this series there was no place for the red, green, and grey slaty rocks of the Llanberis Quarries, for we were still far above them; but it was known that a very considerable thickness of such beds had to be traversed, and below them other slates and slaty mudstones before we reached the great conglomerates which here, as everywhere, occur at the base.

Next to take the section south of the hills south of Bangor.

Near Minffordd there are black shales with traces of graptolites, and on the hill up the road to the north of them are banded sandy flags, behind which, at some distance to the north, the basement conglomerate crops out. Following the black shales to the east we find them well exposed by the road from Bangor to Llandegai; while, close to the "Penrhyn Arms," the banded sandy flags are seen in the road immediately before the hotel, and up the hill by the gardens in front of it, dipping under the black shale. In the descending section, along the cliff under the "Penrhyn Arms" garden, a succession of grey felspathic mudstones come out from under the banded flags and black shales. Bearing more to the west and following the series across the Recreation Ground we found that the black shales (a^{10}) passed down into banded flags (a^{9}) which in their turn passed down into red and grey sandy shales and felspathic mudstones, as shown in Fig. 170; while in and above the road, near the west entrance to the Recreation Ground, and apparently coming out from below them all, we saw the coarse basement conglomerate of the Cambrian (a^{1}), here made up almost entirely of pebbles and quartzite and felsite.

Between the recreation ground and the cliff, near Garth Ferry, are several important faults, the result of which is that the black shales are again met with on the east of the pier, passing down into banded flags. Though there are some interruptions by faults which in the cliff section may throw out some of the series, still, as the faults are oblique to the strike, the beds can be traced up and down beyond their influence, and immediately west of the pier the banded flags are seen to pass down into lenticular beds of exceedingly tough, coarse grit and conglomerate composed almost entirely of quartz. This again passes down into a series consisting of felspathic mudstones very like those on the recreation ground, which pass into the coarse conglomerate which, though perhaps repeated somewhat by faults, is still evidently of great thickness, and forms the cliff up to the great fault that brings on the Carboniferous, as seen in Fig. 171.

In the banded beds close to the pier we found a *Lingulella*, probably *L. lepis*.

All basement beds are, from the nature of the case, apt to be very variable deposits. So, as we traced the base of the Cambrian from Bangor, westward to Carnarvon, we found a considerable difference in its character, but fortunately no important change occurred without our having had some previous indication of its coming on.

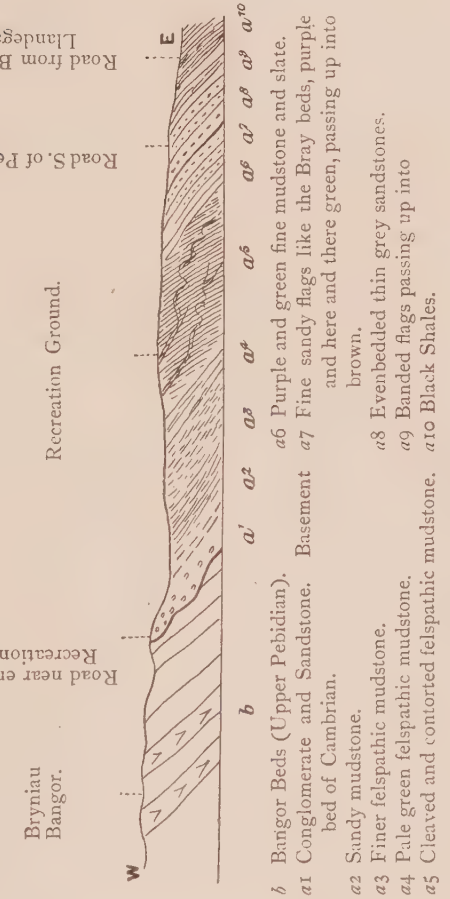


FIG. 170.—DIAGRAM SECTION E. AND W. ACROSS BRYNIAU BANGOR.
Length of Section about one mile. (T. McK. H.)

Following the conglomerate along the south flank of Bryniau Bangor, we found here and there in the rough ground east of Nantgwtherin that the coarse conglomerate, made up chiefly of pebbles of quartzite and felsite, was occasionally in part replaced by a grit consisting mainly of quartz. Having crossed the disturbed ground near Tairffynon, we picked up the conglomerate again on the road up the hill to Brithdir and here again we found a coarse quartz grit associated with it. The conglomerate was seen here and there for some distance to the west, until near Llanddeiniolen it was found strongly developed and quarried close to Tymawr. Behind the conglomerate and dipping under it was a bed of coarse grit

FIG. 171.—SECTION SEEN ALONG SHORE OF MENAI STRAITS, NORTH OF BANGOR.

Length of Section about one mile (T. McK. H.).

*a*1 Conglomerate and Grit (Basement bed of Cambrian).
*a*2 Pale mudstones with purple beds probably equivalent to *a*2 to *a*7 of section No. 6.
*a*3 Conglomerate of quartz and jasper pebbles, and coarse grit.
*a*4 Sandstones and evenbedded mudstones.
*a*5 Banded flaggy shale.
*a*6 Black shaly slate.
C Carboniferous.
x Broken faulted ground.

composed chiefly of quartz, but containing also a large proportion of small fragments of felspathic rock. This section was perhaps the most important of all we visited, for in it we saw a passage from the quartz grit into felspathic grit, and the felsite-conglomerate overlying the grit. In the strike of this grit and conglomerate we came first of all to Archæan rocks, and then to black and red shales which underlie black or banded shales similar to those marked *a*9 and *a*10 on Fig. 170, and *a*4 and *a*5 on Fig. 171. The features of the ground also suddenly changed, and it was clear that we here crossed some very considerable faults. We had not time or data for working out the exact pattern of these faults, and, moreover, we were seeking for evidence as to the sequence of the rocks where the succession was clear, and not working out the structure of the district. The grit was thrown back to Careggoch. It was quite a conglomerate in places, and had hardly any trace of felspathic rocks in it. In the fields in front of it, on the south, black shales appeared here and there. Following the strike towards Carnarvon, we found the quartz-conglomerate in a small quarry in a field above Ysceborwen, about a quarter of a mile north-east of Twt Hill. There were hardly any traces of felspathic rocks like those in the grit of Tymawr, but it contained more fragments of mica-schist, jasper, &c. The granitoid rock was not seen

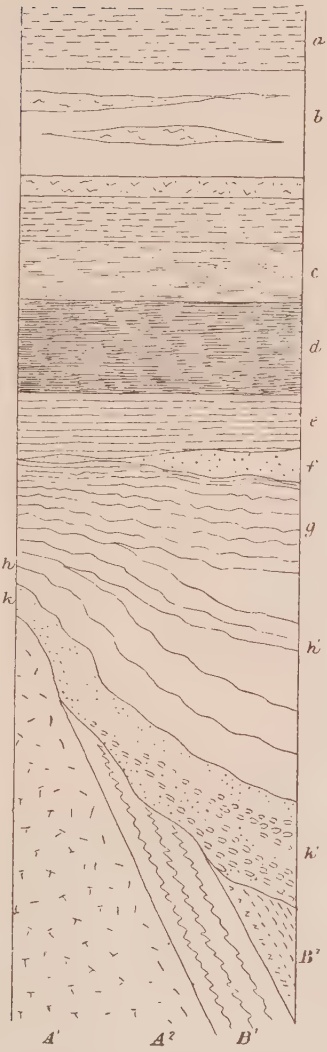


FIG. 172.—GENERALIZED SECTION THROUGH CAMBRIAN OF NORTH WALES.

in the quarry section, but cropped out immediately behind it at the north-east end of the boss. The conglomerate passed up into even-bedded sandstones which were clearly exposed along the hedge in front of the quarry.

Proceeding along the new road which runs for a short distance along the top of the hill above the main Bangor and Carnarvon road we came to a quarry in the granitoid rock, the south boundary of which almost exactly coincides with a fault, so that the face of rock in front of us, as we looked directly into the quarry from the road, consisted at the south-west end of the quartz-conglomerate, while the quarry ended abruptly on our right at a fault partly filled by a diabase dyke.

Crossing a hedge to the S.W. we came to another quarry in a field in which the brown sandstones of the Cambrian basement beds were seen passing down into the quartz-jasper-conglomerates, which were seen resting directly upon the granitoid rock. This conglomerate had been traced still further along the strike to near the church at the other end of Twt Hill.

No higher beds of the Cambrian were seen near these sections, but just outside the town, south of the castle, Arenig beds are well exposed along the road and river. These have

been described by Marr,* who has given a list of fossils from them.

So, reviewing all the sections seen, we made out the following sequence, as shown in the section, Fig. 172.

Notes of Sections seen.	*Probable Equivalents elsewhere.*
a. Shales on the top of Snowdon, with *Orthis flabellulum*.	Middle Bala.
b. Volcanic series on Snowdon down to below the Half-way House.	Ditto.
c. Shales below the Half-way House.	
d. Black Shales, with Graptolites (*Climacograptus cælatus?*). On the flanks of Snowdon, below the Half-way House; at Llanrug, three miles east of Carnarvon; Pont Seiont, south of Carnarvon; and along the stream which runs from below Ffriddodd to the Llandegai Road near the "Penrhyn Arms," Bangor.	Lower Bala. Upper Arenig.
e. Banded flaggy beds close to the "Penrhyn Arms," Bangor; on the hill east of the Recreation Ground and north of the soft black shales above mentioned near Ffriddodd; close to Garth Ferry Pier, where they yielded *Lingulella lepis* (*?*)	Lower Arenig.
f. A coarse, tough grit seen west of the Pier at Garth Ferry; on the flanks of Snowdon, above the road between the Half-way House and the Victoria Hotel.	Garth Grit, probably of the same age as the great grit which runs by the farm of the same name (Garth) near Portmadoc.
g. Black shales above Victoria Hotel, Llanberis, doubtfully referred to this horizon.	? Tremadoc.
h. Bedded felspathic mudstones. Very variable beds, much thicker in the Llanberis district, where they include all the slate-bearing series of which only a few thin representatives are found in the purple beds of the Recreation Ground and of the cliff west of Garth Ferry Pier. The series is	The Menai series comes where we should expect to find the Lingula Flags, Menevian and Harlech, but no exact correlation is possible with only the data before us.

* Quart. Journ. Geol. Soc., vol. xxxii. p. 134.

seen also in the cliff below the garden of the "Penrhyn Arms," Bangor. It has almost entirely disappeared in Anglesey.

k. The Conglomerate series, which are, of course, from the nature of the case, also very variable. In the Bangor district consisting chiefly of fragments of felspathic rocks and quartzites, but as we follow them to the south-west containing more quartz, either in alternate beds or mixed up with felspathic material.

Basement beds of the Cambrian, not necessarily of the same age everywhere.

Thus it appeared to us that although the basement Conglomerate and grit were very variable, yet, by counting down from beds about which there was no doubt, through a series which had a fairly uniform sequence, we could often make out with certainty when we had reached the basement beds, and we commonly found the felspathic pebbles and grains mixed up or interbedded with the quartz pebbles and grains in such a manner that it was clear we must refer the variation to difference of origin not involving difference of age. We, therefore, next enquired on what did these basement beds rest.

In the Bangor district at Ffriddodd, and near the recreation ground, and along both flanks of the hills from Bryniau Bangor to the south-west towards Minffordd on the one side and Careg Hwfa on the other, we found under the Conglomerate chiefly ashes and various coarser and finer felspathic rocks, mainly composed of volcanic ejectamenta. As we followed the basement beds of the Cambrian to the south-west we found cropping out from below them the great felsitic series of Brithdir and Dinorwig. Here the Cambrian Conglomerate, being transgressive over the edges of the Archæan rocks, had overpassed the Bangor Volcanic beds, and was resting upon another and different series. Agreeing with this we found at Tymawr, near Llanddeiniolen, a much larger proportion of the pebble in the Cambrian Conglomerate derived from these felsitic rocks.

Then, after crossing the Llanddeiniolen faults, we had to pick up the line of the base of the Cambrian much further north, and the next series seen coming out from under the basement beds was the fine sub-crystalline rock of Crug. We followed the upper road towards Carnarvon, and in the quarry in a field near

Yscuborwen we saw that the Conglomerate rested upon a coarse granitoid rock, which formed the greater part of the rest of the ridge, along the north flank of which the Conglomerate was seen at intervals to the end of Twt Hill.

Fig. 173.—Diagram Plan showing how the Cambrian Basement Beds crlep over the various divisions of the Archæan between Bangor and Carnarvon.

(T. McK. H.).

So we ascertained that a regular sequence could be made out among the rocks which we come upon below the Cambrian, and that it was as follows, in ascending order (see Fig. 172).

A^1. The coarse granitoid rock which runs near Carnarvon, by Llysmeirion to near Dinorwig.	Twt.	Carnarvon.	Dimetian.
A^2. The finer rock, in which the crystalline structure is not always apparent, but which often shows an approach to the characters of A^1, and sometimes looks like B^1 metamorphosed. Near Crug, north-east of Carnarvon.	Crug.	Carnarvon.	Arvonian.
B^1. Rich black, purple, and pink quartz felsites, often a quartz-felspar-porphyry, sometimes brecciated. A great group, consisting chiefly of lavas. Near Dinorwig, N.E. of Crug.	Dinorwig.	Bangor.	Arvonian.
B^2. Volcanic ejectamenta, from fine ash to coarse agglomerate, but with few lavas. Near Bangor.	Bryniau.	Bangor.	Pebidian.

The microscopic character and composition of these rocks having been described by Bonney and others, we confined our attention to the questions of the succession of the rocks, and satisfied ourselves (1) that there was an obvious sequence in the rocks agreeing with these details of internal structure, and that an ascending section could be traced from Carnarvon to Bangor; and (2) that, whatever difficulties might arise from the probability of there being altered intrusive rocks among the lowest members of the group, and whatever difference of opinion there might be as to the relations of these older rocks to one another, there certainly could be no doubt that the Cambrian was transgressive over them all, and that the variations in the character of its basement beds were just such as might be expected from the character of that part of the underlying group which lay behind it in such a position as would represent the shore from which shingle drifting with prevalent south-west winds would be derived.

Some collateral evidence was gained in our trips to Anglesey. The clear Carboniferous sections of Penmon and the glacial deposits of Beaumaris having been examined, some of the party returned to the more difficult ground between the cemetery and Garth Ferry. The section along the new drive to Baron Hill was followed from above the cemetery, and felspathic mudstones and grits were found in regular succession about halfway along the drive, where they passed down into the felsite-conglomerate. This was cut off by a fault known to be running up from the shore in this direction, and green Archæan schists are seen on the west of it. These appear to be in some places cut off by faults, and in others to be overlaid by Cambrian grits and fossiliferous shales

Shore opposite Garth Point.
Beaumaris.
Penmon.
Puffin Island.
S.W.
N.E.
d d' d d' d e d d c b b a d' a
a Mountain Limestone.
a¹ Grit and Conglomerate in ditto.
b Black Slates (Arenig and Bala ?).
c Conglomerate (? Basement beds of Cambrian).
d Schists, with the various Shales, Sandstones, and Conglomerates (d')
caught in here and there—not yet worked out.
e Dykes (basalt, &c.).

FIG. 174.—SECTION FROM SHORE OF MENAI STRAITS OPPOSITE BANGOR TO PUFFIN ISLAND (T. McK. H.).

along the shore of the Straits to near the end of Garth Ferry, as shown in the two following sections (Figs. 175, 176):—

It is known that precisely the same kind of evidence as that recorded from the Bangor-Carnarvon district can be obtained in the island of Anglesey, but we did not wait to examine it as we traversed the Llanfaelog axis on our way to Holyhead. We saw from the train the coarser porphyritic granitoid rock of Llanfaelog, which there forms part of the gneissic series, and, whether any of the granitoid rocks associated with the Archæan may be intrusive into the Archæan or may be only the extreme result of metamorphism, there is no suspicion roused in that area that they are intrusive into the Cambrian, and for the principal object of our enquiry the question is unimportant, as other rocks of the gneissic series are abundantly found in the Cambrian conglomerate of Orsedd Person, Cefn-Ysgwydd, and other places north-west of Llanfaelog.* So we passed on to examine the relations of the quartzites to the gnarled schists of Holyhead.

It was clear that the beds commonly referred to under the name quartzite in Holyhead Island are not true quartzites, but are largely composed of felspar, their decomposition resulting in the production of china clay. They were, in fact, only a

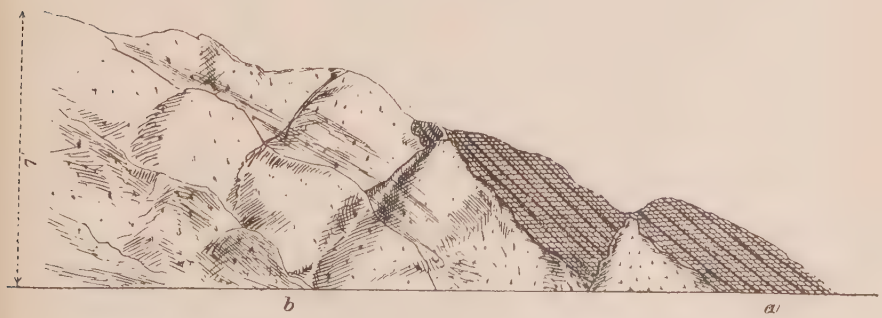
* See Quart. Journ. Geol. Soc., vol. xxxviii. p. 25.

development of the sandy bands in the gnarled schists; so we coined the name felsi-quartzite for immediate use until petrologists give us a better. We examined the line of junction, and it was clear that, unless there was a great inversion of strata, the Holyhead felsi-quartzites passed up into the gnarled schists, as shown in Fig. 174.

FIG. 175.—SECTION ON SHORE ABOUT 250 YARDS N.E. OF GLYN GARTH, ANGLESEY, OPPOSITE BANGOR.

Cambrian { *b* Coarse grit.
c A bed of shale with included round masses up to six inches in longest diameter.
Archæan *d* Greenish gnarled beds.

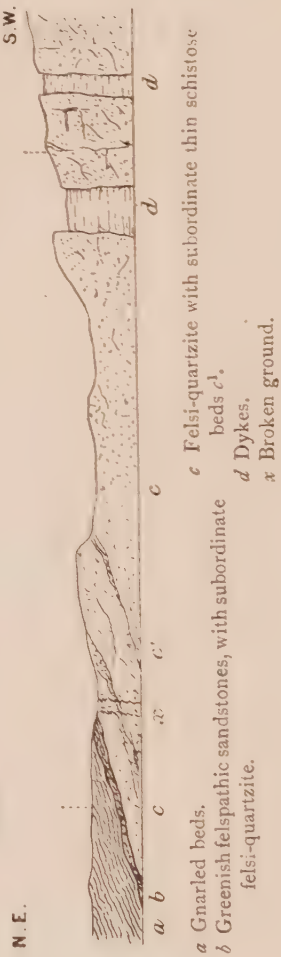
FIG. 176.—SECTION ON SHORE S.W. OF PIER AT ANGLESEY END OF GARTH FERRY.



Cambrian { *a* Black flaggy shale with tracks such as are usually referred to annelids. Crushed junction with *b*.
b Coarse grit, obscurely bedded. Base not seen.

FIG. 177.—SECTION ACROSS JUNCTION OF QUARTZITE AND GNARLED SERIES ALONG ROAD TO GREAT QUARRIES N.W. OF HOLYHEAD.

Length of Section half-a-mile. (T. McK. H.)



Such are the principal results of the investigation; but the members, it can hardly be doubted, came away with the impression that for every good fact we carried away we left a hundred interesting problems unsolved.

On the 28th a large number of the members visited the Penrhyn slate quarry, under the direction of Dr. Hicks. The manager, Mr. J. Evans, conducted them over the quarry, and pointed out the general succession and the effects produced by

several important faults. An interesting collection of specimens obtained from beds at different horizons was exhibited, and the effects of cleavage on rocks composed of different materials explained. The members then travelled up the valley of Nant Ffrancon and examined the glacial striæ so remarkably preserved along the river bed and along the sides of the valley. The ascending succession of the Cambrian rocks was then followed to the well-known *Cruziana* beds, and beautiful specimens of the latter were collected. In traversing this section from west to east along the sides of Nant Ffrancon the following general order of the rocks seemed tolerably clear:—1, The purple and green slates of the quarry (Llanberis); 2, a thick series of grit and flaggy sandstones (Harlech); 3, dark flaggy beds (Menevian?); 4, flags and sandstones, with *Cruziana* (Lingula flags); 5, dark flags (Tremadoc?); 6, black slates and flags, with pisolitic iron ore and grit at base (Arenig).*

References.

Maps.—Ordnance Survey. Geological. Quarter-sheets 77 N.E., 78 N.E., N.W., S.E., S.W., 75 N.E., N.W. 3*s.* each.

New Ordnance Survey. Sheets 92, 93, 94, 105, 106, 119. 1*s.* each.

Books. [The later volumes of the Quart. Journ. Geol. Soc. are full of the literature of this district; full references to all the papers will be found in Woodward, Geology of England and Wales. Ed. 2, 1887, p. 37, &c.]

* See also Dr. Hicks' "On the Geology of the District in North Wales to be visited during the Long Excursion." Proc. vol. viii. p. 187.

MIDLAND COUNTIES.

EXCURSION TO WARWICKSHIRE.

JULY 10TH AND 11TH, 1871.

Directors—The Rev. P. B. BRODIE, M.A., F.G.S., and J. W. KIRSHAW, F.G.S.

(*Proc. Vol.* ii. *p.* 284.)

MEMBERS proceeded to Harbury station, near Leamington, and were there met by the Rev. P. B. Brodie and Mr. J. W. Kirshaw. After partaking of luncheon provided by Messrs. Greaves and Bull, the proprietors of the extensive Lias quarries and cement works of the neighbourhood, the party visited the quarries, where the Lower Lias is exposed to a depth of fifty feet, showing one of the finest inland sections in England. This may be considered a typical section of the "Lima beds" of the Lower Lias, which are seen to consist of alternate beds of a bluish grey limestone and dark-coloured shale and clay. The limestone is quarried for the manufacture of "hydraulic cement," but the clay is not here employed for any economic purpose, though in other places Lias clay is advantageously used for brick and tile making. Palæontologically, the Harbury Lias does not equal in interest the corresponding beds at some other localities. *Gryphæa incurva* is not uncommon in the clay bands and *Rhynchonella variabilis* is the most abundant species in the limestone, while *Lima gigantea*, *L. Hermanni*, *Pecten Pradoanus*, *Plesiosaurus rugosus*, and the genera *Ammonites*, *Nautilus*, *Ostrea*, *Perna*, and *Pinna* are also, though sparingly, represented. The members were invited to inspect the cement works, and afterwards the party proceeded northward along the railway in the direction of Leamington to examine the fine section exposed in the railway cutting near Harbury. As the railway is nearly at right angles to the dip of the strata, which is a slight one to the south, beds lower than those seen in the quarry are exposed, and the section extending for upwards of a mile, the lowest

beds of the Lias, beds of the Rhætic series, and, still further, the Red Marls of the Trias are seen. After this very instructive section had been carefully observed the train was taken to Warwick.

In the evening the Museum in the Town Hall, a building of great antiquity, was lighted with gas for the first time in its annals, to allow of an inspection of the valuable collection of Triassic and other fossils there deposited. The organic remains from the Triassic rocks of Warwickshire, on account of their extreme rarity, give a special character and high palæontological value to the Warwick Museum. These fossils consist chiefly of the remains of the Labyrinthodonts, of Ichnites or footprints of Cheirotherium, and of the little crustacean, *Estheria minuta*, once thought to be a mollusc, and called for a time *Posidonomya minuta*. But in addition to these the Warwick Museum contains a fine typical collection of the characteristic fossils of each British formation.

A list of organic remains obtained from the Trias of Warwickshire, and preserved in the Warwick Museum and the collection of the Rev. P. B. Brodie, will be found in Proc. Geol. Assoc., vol. ii. p. 286.

In the Museum of Practical Geology, London, there are fossils from the Permian of Exhall representing the following genera: *Calamites*, *Lepidodendron*, *Sternbergia*, and *Strophalosia*.

On the following morning a visit was paid to Warwick Castle. The castle stands upon a cliff of Keuper Sandstone, which is cut through by the road from the lodge, along which a section of this important member of the Trias may be observed. Subsequently the party left Warwick for Wilmcote, where extensive quarries in the Lower Lias, similar to those at Harbury but exposing still lower beds, are situated. In the sections at Wilmcote an exceedingly interesting bed, wanting at Harbury, is found. This is the "Insect bed" of Brodie, who has obtained from it a large and valuable collection of insect remains. The Insect bed is almost the lowest bed of the Lower Lias, and reposes upon the "White Lias" bed at the top of the Rhætic series. Saurian remains are here frequently met with, and some members obtained good specimens of the jaw of *Ichthyosaurus*. The sections along the railway between Wilmcote and Stratford-on-Avon were next examined. In these exposures the *Cardinia ovalis* bed, the Insect bed, the "black shales" of the Rhætic series, and the *Estheria minuta* band of the Keuper marls are well seen. Under the guidance of Mr. Brodie, *elytra* of insects were found without

much difficulty in the Insect bed, and some very good specimens were secured. On arriving at Stratford-on-Avon visits were paid to the birthplace of Shakespeare, and to the church where the tomb, as well as the baptismal register of the great bard, are to be found, and the return to Warwick was made by way of Charlcote Park.

The members had been invited by Mr. Brodie to inspect his collection of fossils, and those of the party who remained until the following day and visited Rowington Vicarage were highly gratified with their inspection of Mr. Brodie's museum, which contains, as a portion of a large general collection, the Lower Liassic insect remains which that gentleman has made special objects of search and examination during many years, and which he has very carefully figured and described.

References.

Maps.—Ordnance Survey. Geological. Quarter-sheets 53 N.W., S.W., 54 N.E., S.E. 3*s.* each.
New Ordnance Survey. Sheets 183, 184. 1*s.* each.
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EXCURSION TO NORTHAMPTONSHIRE.

May 25th and 26th, 1874.

Director—Samuel Sharp, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 123.)

On meeting the party at Blisworth Mr. Sharp proceeded to give an outline, illustrated by a diagram, of the formations in the district through which he proposed to act as Conductor. In order to facilitate an understanding of the sections in the pits and quarries subsequently visited during the two days' excursion, the substance of his remarks explanatory of the geology of the district is subjoined:—

"Proceeding upwards from the clays of the Upper Lias we have a series of beds which, as developed in the neighbourhood of Blisworth and Northampton, sometimes attain a total thickness of eighty feet. These consist in their lower portions of ironstones, often of great commercial value. The middle portions yield a

red building-stone, much used in, and very characteristic of, the county, whilst the upper portion consists of white sands, frequently containing a plant bed, and usually characterised by vertical plant markings. This latter is designated the 'Lower Estuarine Series,' the whole group being referred to the Inferior Oolite. Throughout the country about to be visited, extending from Blisworth in the S.W. to Stamford in the N.E.—points upwards of forty miles apart—the sequence above detailed holds true in the main for all portions of the district. When, however, we get above the Lower Estuarine bed an important difference is observed to occur. At Blisworth and Northampton, reposing immediately, and perhaps unconformably, on the last-mentioned bed, occurs a bed of blue clay, containing wood, plants, and bands of shells, some of which are said to be fresh-water forms (*Cyrena*, &c). A ferruginous band occurs at the base. This clay has received the name of the 'Upper Estuarine Series.' It is succeeded by about twenty-five feet of a white, marly limestone, full of marine shells; above which, where the sequence is complete, is another clay, with abundance of *Ostrea subrugulosa*. These three beds, viz., the two clays and the intermediate limestone, are referred to the Great Oolite. Above all, there is frequently a capping of Boulder Clay. As we proceed north-eastward, however, it is found that the beds called Upper and Lower Estuarine are no longer in contact, but that there is intercalated an Oolitic Limestone, which presently assumes considerable importance, and at Stamford, on the N.E. extremity of the district under consideration, attains a thickness of seventy-five feet."

The formation last referred to is called the Lincolnshire Limestone, but as no portion of it would be seen on the first day of the excursion Mr. Sharp deferred making any further remarks and gave the word to proceed to inspect the Blisworth Ironstone Diggings, about a mile and a-quarter east of the station. A few men were at work in this quarry, which has a face, including the "baring," of about thirty feet. The base, or junction with the Upper Lias was not actually observed, but the Lower Estuarine is seen at the top. The ironstone exists principally as a sesquioxide, and that portion selected by sifting is said to contain as much as 40 per cent. of metallic iron. Few, if any, fossils were found by the party in this quarry, although Mr. Sharp has from time to time obtained many—all, or nearly all, as casts.

About a mile further on a quarry in the Great Oolite Limestone, worked chiefly for building-stone, was visited. Here the party

had an opportunity of observing about eighteen feet of Boulder Clay, between which and the limestone there occur about eighteen inches of clay referred to the period of the Great Oolite. Several characteristic fossils were found in this quarry. On his way back to the station and to Northampton Mr. Sharp pointed out some buildings where the white limestone of the Great Oolite and the red stone of the Inferior Oolite have been used in alternate layers, with great effect of contrast.

The town of Northampton, at present containing a population of about 45,000 inhabitants, is favourably situated upon an angle of high ground, sloping rapidly towards the River Nene on the south and towards the northern branch of the Nene on the west. The valleys of these streams are excavated in the Upper Lias. The bulk of the town, therefore, rests upon the sands of the Inferior Oolite, including under that grouping the ironstones, or their calcareous equivalents, and the Lower Estuarine Sands. This mass of rock, thus forming an escarpment of moderate slope towards the south and west, is further eaten away by denuding agents—on the north towards Kingsthorpe, and on the east just beyond Abingdon—to such an extent as to form a peninsula with a connecting isthmus not much over a quarter of a mile in width. Such a position would have great military advantages in the Middle Ages, and has probably had much to do with the historical importance of this ancient and celebrated town. It is a peninsula of Inferior Oolite, rising out of a sea of Lias.

The afternoon was dull, so that the views afforded of the country were comparatively limited, and the general features of its surface sculpture not so obvious as would have been the case in clearer weather. Before doing anything geological the party visited the "round church" of St. Sepulchre, supposed to have been built in the time of William the Conqueror. The first group of excavations visited all lay on the north side of the town. The lowest of these is the Kingsthorpe Brick-pit, where the ferruginous beds of the Northampton Sand are seen in contact with the Upper Lias, on which they repose. This is the only one of the numerous sections hereabouts where the actual contact was observed. There seems to be a rubbly broken bed about the junction, which may be a distinct passage bed, or merely the disturbed upper surface of the Lias Clay mixing with the Northampton Sand above. Unless there is a fresh vertical face at some distance below the actual surface of the soil, the indications are more or less obscure. The Nursery Pit is a continuation upwards of the Northampton

Sand of the last pit. The beds here are ferruginous, but chiefly calcitic sandstones, largely false-bedded, and sometimes Oolitic in texture. There are several vertical pipes to be observed—a phenomenon common enough in chalk-pits, but the peculiarity here is that the upper ferruginous beds are not attacked by the solvent, and consequently form a sort of a bridge at the top of the pipes. No fossils were found in this quarry.

In the Kingsthorpe Sand-pit the white sandy Lower Estuarine was observed, with its characteristic carbonaceous beds, from which a few species of Oolitic plants have occasionally been obtained. A considerable mass of compact red sandrock was here noticed; this runs into loose white sand both above and below. Continuing to ascend, the party, on the high grounds of Kingsthorpe (Moulton Park), again made the acquaintance of the Great Oolite Limestone, and those who were intent upon fossils found these marly cream-coloured rocks much better hunting-ground than the sandy, irony, and calciferous beds which go to make up the Northampton Sand of the Inferior Oolite. *Rhynchonella concinna*, *Modiola imbricata*, *Myacites calceiformis* and *Ostrea Sowerbyi* were to be picked up in abundance. Besides these, specimens of *Clypeus Muelleri*, the characteristic *Pinna ampla*, *Myopsis dilatatus* (stunted specimen), *Isocardia tenera* and several others were obtained. Mr. Sharp pointed out also a hard semi-crystalline bed, crowded with *Alaria*, *Nerinæa*, *Astarte* and other shells, but in such a matrix as to defy extraction without time and proper appliances.

Descending eastward, the Boughton Green Quarry was visited, where, as in the Nursery Pit previously noticed, the base of the Northampton Sand appears as a limestone more or less sandy, and not obviously fossiliferous. Indeed, up to this point not a fossil had been secured by any of the party from the Northampton Sand as evidence of its geological horizon. At Bass's Pit, however, nearer Northampton, a single specimen of the very characteristic *Rhynchonella cynocephala* was secured. Yet, by watching carefully, Mr. Sharp has obtained from these pits and elsewhere a large series, in species more numerous than have been obtained from the much more fossiliferous Great Oolite above.

This completed the inspection of the north side of the town, through which the party now passed out towards the west, not, however, before making a pilgrimage to the tomb of William Smith, "The Father of English Geology," who, whilst journeying

to a meeting of the British Association, was in this town arrested by death, and buried in St. Peter's Churchyard.

The Duston Quarries presented the most imposing section of the ironstone series of the "Northampton Sand" visited during the excursion, having twenty-two feet of ironstone alone. A few words, therefore, on the mineral condition and palæontology of these beds as developed in the neighbourhood generally may here find an appropriate place. Amongst the few fossils secured were *Pecten personatus* and *Gervillia Hartmanni;* but, as in all other quarries of this stone, there were very few to be found. Mr. Sharp's collection, however, is so rich as to supply all that is required for reading the life history of the period to which these beds must be assigned. The majority of fossils from this place occur as casts. Judging from data thus supplied, there can be very little doubt that these beds belong to the Inferior Oolite, and to the lowest zone of that formation, as might indeed have been inferred from their resting immediately on the Upper Lias Clay. It is not quite clear whether the passage or "Opalinus" beds should be included, but, as *Ammonites Murchisonæ* occurs tolerably high up in the ironstone, that is at least probable, and many other facts, such as the occurrence of *Rhynchonella cynocephala*, point in the same direction. *Cardium Buckmani*, *Pholadomya fidicula*, *Ceromya bajociana*, *Isocardia cordata*, *Terebratula ovoides* (*T. trilineata* of Young and Bird), and numerous species of *Lima* and *Cucullæa*, peculiar to the Inferior Oolite, all tend to prove the true position of the ironstone; which indeed could never have been assigned to any other formation if the extensive series of fossils obtained since the working of these numerous quarries had been available at an earlier period. Their resemblance in many respects to the "Dogger" of north-east Yorkshire is most remarkable, as was some time ago pointed out to Mr. Sharp by Dr. Lycett. This latter fact suggests many reflections as to the original condition and subsequent metamorphism of these very singular beds. At present, the bulk of the mass consists of a yellow friable earth, partly sandy and partly Oolitic, seamed in all directions by hard bands, consisting chiefly of hydrous peroxide of iron. This, when sifted, constitutes a considerable portion of the commercial ore, and contains, perhaps, somewhat under 40 per cent. of metallic iron. About 1,800 tons of it are raised weekly in the Duston quarries. In some places there occurs a line of nodules of ferrous carbonate, and in the Duston quarries a very striking feature is a

thick band of greyish-green ironstone, low down in the series, which is rejected on account of the quantity of phosphoric acid which it contains. This is, for the most part, a carbonate of iron, with perhaps some silicate. Such is a very brief outline of the present condition of the beds. That this condition is the result of chemical changes, occurring at more than one period in the history of these rocks, the traces of so many organic remains prove most conclusively. And here the study of the contemporary (in a geological sense) ferruginous Oolites of Yorkshire may help us much. Taking the Dogger beds at Blue Wyke, we find an arenaceous Oolite, in which there is hardly any lime. The grains there consist almost entirely of ferrous carbonate. It might be contended that this is a condition of original deposition. Fortunately, there is a fine series of the shells of mollusca in these beds, which have undergone a similar change, and are almost wholly converted into spathic iron. The legitimate inference is that a salt of iron has replaced a salt of lime wherever the latter was present in the rock. The source of such vast quantities of iron is a more obscure question; but as the iron undoubtedly is there now, whether it arrived by deposition or replacement matters little. It must be borne in mind that most, if not all, of these Oolitic ironstones, either in Yorkshire or Northamptonshire, are overlaid by porous sandy beds, which frequently contain considerable traces of carbonaceous matter. This probably is but a vestige of what once existed in the peaty beds accompanying "estuarine" conditions. Layer after layer of micaceous sands, rich in iron, have been permeated by organic acids, the products of the decomposition of these vegetable masses which, attacking the mica and any such basic minerals which might be present, removed their more soluble constituents, and thus, by perpetually exhausting the sands, left those bleached and partly coherent masses which so often overlie the ironstone beds. This is probably one source of the iron, as the solution, originating in the manner described above, the ultimate decomposition of which would most probably result in the formation of carbonates, might possibly, in the presence of an excess of carbonic acid, decompose and replace any porous lime carbonates it might meet with in its descent. The presence of an impervious bed of clay at the base of such rocks would materially facilitate the operation, by keeping the original Oolite in a sort of bath, containing a solution of the replacing salt; though, of course, the hydrostatic pressure of the water would ultimately force the solution containing the

intruded mineral to find an exit somewhere along the lines of least resistance, or it might be removed by simple diffusion in cases where the pressure was equal on all sides. The Yorkshire Oolitic ironstones remain carbonates still in many cases, probably because they have a great mass of rock above them. Those in Northamptonshire have undergone a second chemical change, principally from the action of oxygenated waters, which have had the curious effect of producing a sort of centrifugal motion of the resulting oxide, which enables the owner to get rid of a good deal of foreign matter by the simple process of sifting.

The last place visited was Watkin's brick-pit, where the Upper Estuarine clay is capped by a few feet of Great Oolite; close by is a pit of Lower Estuarine, separated from the Upper by a ferruginous band, not observed on this occasion.

Mr. Sharp then conducted the party to Dallington Hall, where he and his family hospitably entertained the members. The rest of the evening was spent in inspecting Mr. Sharp's magnificent collection of local fossils.

On the following day an early start was made by train for Stamford, about forty miles distant. The line runs due north as far as Market Harborough, through an undulating country, chiefly in the Upper Lias, yielding no good sections by the way. A sort of escarpment of the Northampton Sand flanks the route on the east as far as Maidwell, where the first indications of the Lincolnshire Limestone put in an appearance. In this neighbourhood the country is extremely fertile and beautiful. All this wealth of soil must be due to the mixing of the rich clays of the Upper Lias with the sands and calcareous matter derived from the destruction of the once overlying beds. From Market Harborough to Stamford the mean direction of the route was N.E., and chiefly along the Welland valley, which is flanked on the S.E. by a fine escarpment capped by the Lincolnshire Limestone, on the edge of which Cottingham, Rockingham Castle, and Gretton are commandingly perched.

Arrived at the Stamford station Mr. Sharp drew attention to the great dislocation which has occurred on the south side of the Welland valley, and which may be partly traced to the railway cutting. The general effect of this dislocation is to divide the Inferior Oolite beds of St. Martin's from those at the top of the hill on the London road, a mass of Upper Lias being wedged in between them. This was also observed as the party ascended the

hill towards Lord Exeter's ironstone quarries, which were visited, as also a quarry for road metal, where the party first made the acquaintance of the Lincolnshire Limestone, here a pale-coloured Oolite, not very fossiliferous. The ironstone section was poor compared with some the party had visited during the previous day, nor does it appear that there are any very valuable quarries in the "Northampton Sand" hereabouts. After luncheon at the George Hotel, once a celebrated coaching house, on the site of the ancient hostel of the Abbey of Croyland, the party drove through Stamford, which might be described as the stone town or city of churches, and up the hill on the north to the top of Stamford Field. From the level of the Welland to this plateau there is a rise of about 200 feet vertical, made up of the following beds in descending order :—

Great Oolite series.	Cornbrash—just a cap on the summit.	
	Great Oolite Clay—not exposed.	
	Great Oolite Limestone—base just seen.	
	Upper Estuarine series—Torkington's brick-pit.	
Inferior Oolite series.	Lincolnshire Limestone—many quarries.	
	Lower Estuarine Ferruginous beds	Northampton Sand.
	Upper Lias Clay—a few feet.	

Torkington's brick-pit presents an interesting section of about twenty-five feet—principally variegated clays, referred to the Great Oolite, and traced by the Geological Survey to the horizon of the Stonesfield Slate. It is known in Mr. Sharp's memoir as the "Upper Estuarine," is of variable composition and thickness, frequently sandy, and is always found in this district underlying the Great Oolite Limestone. Several of the clay bands are pierced by vertical carbonaceous markings, and are also shelly; some fossils were picked up, but their condition was such as to render them very difficult of identification. *Modiola imbricata* and other bivalves were amongst them. The brackish-water genus, *Cyrena*, was found. The last two excavations visited within the Stamford area, north of the town, are quarries in the Lincolnshire Limestone. In Simpson's quarry, from which is obtained some of the best building stone in England, and the beds of which are geologically the same as those at Ketton, viz., the upper part of the Lincolnshire Limestone, the blocks obtained are of great size, very uniform in their composition, consisting of a fine-grained Oolite, and ring like a bell when struck with the hammer. Above the

Limestone occur about fifteen feet of the Upper Estuarine Clays, with a ferruginous band towards the base, as is usual. About the line of junction there is often a thin band of white friable aluminous earth, somewhat of the nature of *Scarbroite*. In Tinkler's quarry still lower beds of the Lincolnshire Limestone are obtained, including a Shale bed, said to contain many shells, well preserved, but crushed. Below this is a hard blue-hearted limestone containing coral, *Nerinæa*, and many other fossils—the "Stamford Marble." Some fragments of coral were obtained by the party, but neither here nor in the other quarry were the spoils of the Lincolnshire Limestone of much consequence. One or two casts of *Natica leckhamptonensis*, a specimen of *Lucina Wrighti*, and a doubtful *Trigonia*, were about all that came under the reporter's notice. These and adjoining quarries have, however, been watched for a number of years by careful palæontologists, and notably by Mr. Sharp, Mr. Bentley, and Professor Morris. It is in their collections, and especially in that of Mr. Sharp, that the evidence of the geological horizon of the Lincolnshire Limestone must be sought. For many years there was a general inclination to class these important beds (the Lincolnshire Limestone) with the Great Oolite: but the Geological Survey has ultimately decided to place them at the top of the Inferior Oolite formation, of which, throughout the county of Lincoln, they form by far the most important member. Notwithstanding the apparent poverty of fossils in the limestone quarries of Stamford, no less than 315 forms have been noted by Mr. Sharp from all parts, including, of course, the Collyweston Slates, a local group at the base of the series. One of the most remarkable features of this extensive fauna is the scarcity of Cephalopoda, especially of ammonites. *Ammonites terebratus*, Phill. (*A. macrocephalus*, Schlot., *A. Herveyi*, *Sow.*), marked as occurring, is a characteristic Cornbrash form. *A. Murchisonæ* and *A. subradiatus*, however, are the two other species quoted, and these represent different zones of the Inferior Oolite.

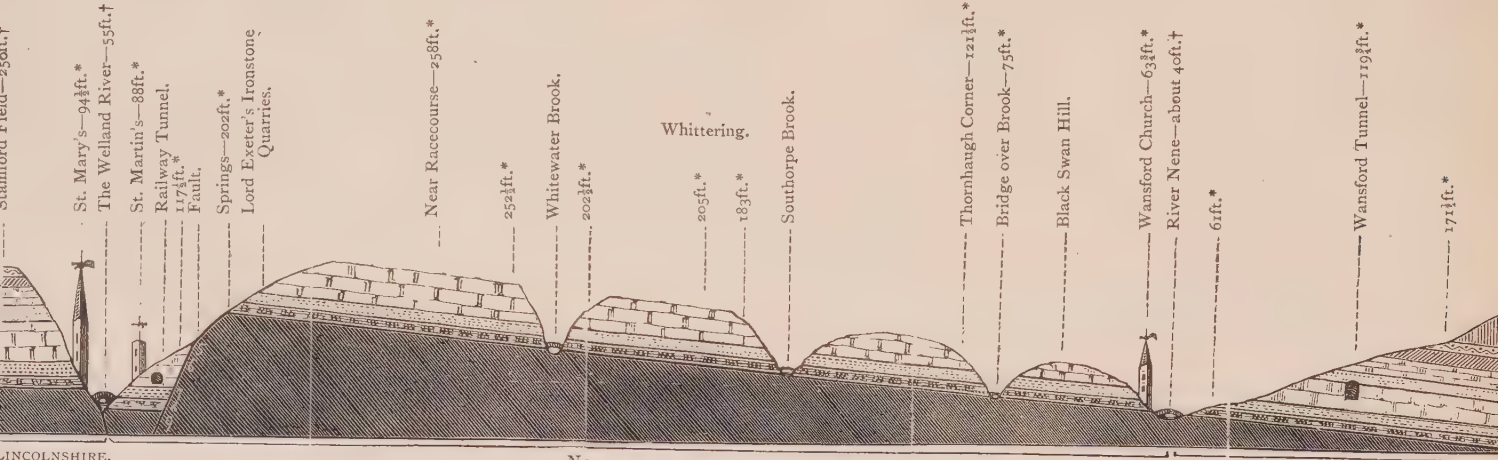
Driving through Stamford, the party mounted the great plateau on the south side of the Welland, on which is situated the village of Collyweston, some four miles distant.

The Collyweston "slate" is a sandy, laminated limestone, very hard, and sometimes blue-hearted. Lithologically it is not unlike Stonesfield Slate. As the Association had visited Stonesfield at Easter, those who attended both excursions had a good opportunity of comparing the two "slates." The state of the fossils

FIG. 178.—SECTION FROM LINCOLNSHIRE AT STAMFORD THROUGH NORTHAMPTONSHIRE INTO HUNTINGDONSHIRE, NEARLY ON THE LINE OF THE GREAT NORTH ROAD.

Horizontal scale, one inch to a mile. Vertical scale, about one-tenth of an inch to thirty feet. Heights, above mean sea-level at Liverpool, taken from Ordnance Survey Bench-marks.

N.N.W. STAMFORD. S.S.E.



1. Oxford Clay.
2. Cornbrash.
3. Clay.
4. Limestone. } Great Oolite.
5. Upper Estuarine.
6. Lincolnshire Limestone and Collyweston Slate.
7. Lower Estuarine. } Northampton
8. Ferruginous Beds. } Sand. } Inferior Oolite.
9. Upper Lias Clay.

* Heights above sea-level—taken from Ordnance Survey List of Bench- marks.

† Heights above sea-level—estimated from neighbouring Bench-marks.

‡ The Huntingdonshire portion of the Section is contracted about three-quarters of a mile.

N.B.- The datum line represents the mean sea-level at Liverpool.

(occurring chiefly as compressed casts) is exactly the same, and altogether there is a general external resemblance, which is very striking. Moreover, in each case, fossils are very abundant, but of a somewhat different *facies*. *Gervillia acuta* occurs plentifully in each, and there is likewise here a *Trigonia* not unlike *T. impressa* of Stonesfield, but beyond this point there is not much resemblance in their respective faunas. The party collected several species, as *Hinnites velatus*, *Pinna cuneata*, *Avicula braamburiensis*, *Ceromya sp.*, *Cardium Buckmani*, *Cucullæa cancellata*, *Modiola Sowerbyana*, *Trigonia pullus*, *T. compta*, and, most characteristic of all, *Pterocera Bentleyi*. Plants and some teeth and scales of fish occur, but the formation appears deficient in the remains of insects, reptiles, and mammals, which are the glory of the Stonesfield beds. After a drive through Ketton, and thence along the Stamford and Uppingham high road to Luffenham station, the party took the rails once more and arrived at Northampton.

In thanking Mr. Sharp, his claims as having contributed so materially to a proper understanding of Lower Oolite geology in the Midland Counties were pointed out. The Lower Oolitic region of the Cotteswolds, and of the S.W. generally, had long been the classic ground of geological study. There the formation is chiefly marine in its types, and in that region the Great Oolite group is well developed. For this reason, perhaps, when geologists sought to correlate the Lower Oolites of the rest of England with the typical districts, they were apt to refer too much to the Great Oolite. Hence, in Yorkshire, where the organic beds are few and fossils comparatively rare, or at least difficult to procure, Professor Phillips referred most of the series to the Great (or Bath) Oolite. At a subsequent period Professor Morris, in describing the sections on the Great Northern Railway, noted the important beds of limestone south of Grantham ; and, although that eminent palæontologist was much struck with the important differences presented by the fauna of these beds to what obtains in the typical Great Oolite districts of the south-west of England, he seems, though with much hesitation, to have referred them to the Great Oolite. Subsequently, not being entirely satisfied, and knowing the great difficulty there must be in reconciling the phenomena of the north-eastern and south-western Oolitic areas, he ventured to predict that the key of the arrangement was to be sought in the district between Northampton and Stamford, the very district traversed by the excursion that day. It was shown

that Mr. Sharp and Prof. Judd had succeeded in finding that key, which had unlocked the mystery that had puzzled geologists for so many years. This was no less than the laying down and defining the boundaries of that remarkable mass of limestone, which, commencing in a thin bed a few miles N.E. of Northampton, henceforth divided the two estuarine series, and at Stamford has already attained a thickness of seventy-five feet.

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Sharp, Sketch of the Geology of Northamptonshire, Proc. Geol. Assoc., vol. iii. p. 243.

EXCURSION TO CHARNWOOD FOREST, LEICESTERSHIRE.

Whit Monday, May 17th, 1875, and Two Following Days.

Directors—James Plant, F.G.S., William Harrison, and William Molyneux, F.G.S.

(*Report by* W. H. Hudleston, F.R.S.)

(*Proc. Vol.* iv. *p.* 307.)

The party, under the guidance of Messrs. Plant and Harrison, met at Desford station on Whit Monday, and proceeded in carriages to Lindridge Colliery. Mr. Mammatt, the engineer of the company; Captain Marshall Hall, one of the directors; and Mr. Shore, on whose property the sinking is made, were also present, and afforded every facility for the examination of the new works connected with the colliery. As this is a sinking through the Trias in a district not hitherto wrought for coal, the following section of the bore hole, furnished by the kindness of the above-named, is given :—

Began April 10th, 1874. First coal found May 14th.

	Ft.	in.	Strata.	Ft.	in.
Keuper	0	0	Red and Grey Marls . .	50	2
	50	2	Smooth hard grey skerry .	6	6
	56	8	Red Marls (Gypsum) } .	86	10
	90	0	*Strong Spring* }		
	143	6	Grey Sandstone . . .	36	6
	180	0	Red Marls *(Spring)* . .	78	0
	258	0	Limestone	1	0
	258	0	Red Marls	17	0
Coal Measures	278	0	Sandstone (plants) . .	9	0
	287	0	Coal	4	0
			Parting	2	0
	291	0	Coal	8	6
	301	6	Grey Rock . . .	27	10
	329	4	Coal	4	0
	334	0	Grey Bind	35	0
	333	4	Limestone	0	8
	360	0	Coal	3	0
	372	0	Limestone, with fossils Grey Rock. .	1	0

The position of Lindridge is four miles south-west of the last continuous boss of the Charnwood ridge at Groby. Two borings were made, about one mile apart. At the most easterly the "hard bind" of the Coal measures was found dipping at a very high angle, and no further boring continued there. One mile to the westward, where the present sinking was being made, the beds are flatter, being further from the Charnwood axis, which is continued under the Trias, several miles south of Groby as indicated by small bosses of fine-grained crystalline rock appearing on the surface.

The following remarks made by Mr. Plant serve to explain the physiography and general geology of the district: "We now stand about eighteen miles from the river Trent, the north boundary of the district, and about three miles from Charnwood Forest, which bounds it on the east side. On the west flank is the Hartshill range, a little less elevated than the Charnwood, the average height of the latter being about 600 feet, the former 400 feet, with an indefinite boundary towards the south, embracing an area of about 200 square miles, which comprises the Leicestershire coalfields. To the north of us the Coal measures come out at the

surface. On the east the Charnwood Forest or Coleorton field extends, while the Moira stretches on the western side. The southern portion lies under the New Red formation, being covered by the uppermost beds of the New Red Sandstone. Forty years ago a practical miner and distinguished railway engineer predicted that there was no coal to be found south of this point in this direction. The Bagworth coalfields are the answer to that erroneous opinion. There, coal is found at a depth of 320 feet below the red marl, where it must be noticed there are no Bunter or Permian strata. With reference to this Lindridge colliery I was afraid that the ridge of igneous rocks extending from Groby due south and which might be reached near Lindridge, would be struck, and so coal would not be accessible. However, that fear has fortunately proved to be groundless, as the evidences around us testify. You must not suppose that this is the most southerly extension of the coalfield, as it is found six miles further south. Before concluding, I might just remark that you are now standing upon the Waterstones commonly called the Lower Keuper Sandstone, upon ripple-marked beds indicating old sea-beaches of the formation. Here it is possible for you to find the footprints, jaws, and feet of the *Labyrinthodon*."

The party then adjourned to Lindridge Hall, where they were hospitably entertained by Mr. Shore.

An adjournment now took place to the ground, where cores of rock obtained in the boring were exhibited. Here Mr. Molyneux gave a brief account of the Coal measures of the district.

It was already rather late in the afternoon before the party arrived at the syenite quarries of Groby, the southern termination of the Charnwood range. Immense quantities of paving stones are quarried from these rocks, which are true syenites, *i.e.*, binary compounds of orthoclase and hornblende. There is, of course, considerable variety in the different beds, as well as change in the system of jointing. Besides the ordinary syenite made up of good-sized crystals, a handsome rock, there are beds of a very fine-grained variety which seemed to occur athwart the general system of bedding. In the second pit the jointing is more vertical, though the character of the rock is much the same. The Rev. T. G. Bonney writes: "I have examined microscopically the Garendon and Groby syenites—true syenites, though much altered—'messed,' I might say, subsequently." The rock generally appears

to consist of a flesh-coloured felspar, with good cleavage, and of a certain amount of hornblende, which, where undecomposed, is nearly black. The hornblendic element seems, however, to have undergone a considerable amount of alteration—decomposition, one might rather say—the result being the production of a green-coloured mineral, which has largely stained the felspar. Pink and green, therefore, are the predominating colours, justifying to a certain extent the name of "syenitic greenstone," which has been applied to this rock. The joint faces are often lined with a green mineral matter, which sometimes resembles epidote and sometimes is of a serpentinous character. All these may be looked upon as altered products from the original hornblende, produced in the "wet way," and have nothing to do with the original formation of the rock, which has all the character of an igneous one.

One very interesting feature here is the Upper Keuper Sandstone, which may be seen to rest upon the upturned edges of the old rock, in positions suggesting a sort of quaquaversal dip away from a rocky islet in the Triassic Sea. Between the syenite and the Triassic sandstones and marls there is a conglomerate of pebbles and boulders, chiefly made up from the neighbouring rock, in a pasty matrix, somewhat analogous to the Dolomitic conglomerate of the Mendips.

A short drive brought the party to Newtown Linford, situated in the anticlinal valley of the Charnwood range, now wholly filled with beds of Keuper age, where all dismounted and entered Bradgate Park on foot. Here an immediate change in the character of the landscape proclaimed the presence of that great body of syenite which constitutes the southern termination of the eastern wing of the Charnwood range, just as the Groby syenites are the southern termination of the western wing. Ragged, splintery edges of rock start out of the steep hill-side, which is dotted with oaks short in stature and most picturesquely gnarled, a bit of Cambria or Caledonia in the midst of the rich Midland of England. The ruins of Bradgate Hall are close by. The place was set on fire, tradition says, by a former countess, who found the country dull and wished to return to more animated scenes. Further on the slaty beds of the Charnwood series occupy the surface. Near "Old John Hill," which is the highest point of Bradgate Park, we find the cleavage planes dipping north, whilst the beds dip to the south, at an angle of 60°. In some places there is a remarkable ribboned appearance, due to variegated

colouring in the bedding planes. Hereabouts the cleavage is often very imperfect and coarse. It was noticed by several members of the party that these slates have a very "ashy" appearance, not unlike those of the volcanic rocks of Cumberland, now so well known through the labours of Mr. Clifton Ward, of the Geological Survey. The view from Old John Hill is magnificent; and Mr. Plant enlarged upon the physiography of the district, dwelling especially upon the configuration of the country as it had been left by Glacial erosion.

The party now proceeded to the great wood of Swithland, where there are several slate quarries. The one visited is a great excavation, 150 feet deep. The general dips here are about 45° in an easterly direction. It was too dark, however, for much accurate observation.

Tuesday, May 18th.—The party proceeded by the Leicester and Burton branch railway to Bardon Hill station. The first thing inspected was an old road-stone quarry in the slate, now converted into ornamental grounds. This is at the foot of Bardon Hill. The cleavage of the slates is very imperfect, but the bedding is distinct, with a strong dip to the S.W., *i.e.*, away from the great boss of Bardon Hill. Amongst other objects of interest in this section is a band of old conglomerates, containing a number of rounded pebbles. A specimen of one of these pebbles consists almost entirely of pink orthoclase and vitreous quartz—no mica or hornblende. This was *in situ*, but amongst a group of stones forming a rockery were some specimens of the so-called slate from near the top of Bardon Hill, which was a typical volcanic breccia, or rather an "ash," with large, included fragments precisely similar to examples from the volcanic rocks of Cumberland. Unfortunately, no actual junction between these slates and the Bardon Hill stone was observed. This stone is quarried exclusively for road metal, since it cannot be broken into cubes, as are the syenites. On the Survey map it is indicated as a greenstone. The Rev. T. G. Bonney writes: "The greenstone of Bardon Hill is a felstone; it has orthoclase and much quartz in it. I rather think it is the stump of a plug or cone, for there is much agglomerate on one side of the hill." It is less distinctly crystalline than the syenites of Groby, or the syenitic granite of Mount Sorrel. The prevailing green colour is probably due to the subsequent decomposition of small quantities of hornblende, or other magnesia lime silicate, the resulting green hydrous silicate being more or less diffused throughout the whole rock. This description is

not, however, applicable to the whole mass, as there are many varieties; some in the vicinity of quartz veins presenting mineralogical features of much interest. The green colour, in some instances, also may be due to the presence of a mineral of the epidote class. A system of planes, dividing the rock into large slabs, dips inwards in a direction of E.N.E.; and intercalated between these planes in one place, near the entrance of the quarry, is a parallel mass of rotten foliated rock associated with quartz. This has been called mica schist. It is rather rich in magnesia, with a considerable amount of ferrous oxide, but is poor in lime, silica and alumina being, of course, the principal ingredients; and it may be viewed, perhaps, as a sort of talco-micaceous schist.

The ascent of Bardon Hill, the highest point in the forest—854 feet above sea-level—had formed part of the programme, but the weather was so unpropitious that the ascent had to be abandoned, together with the intended walk to see the "porphyrite" rocks of Greenhill. Of these Mr. Bonney writes: "The porphyrite rocks are not igneous, only extremely metamorphosed, and, so far as I know, are not conspicuous for plagioclase felspar, therefore they should not be called porphyrites."

It is somewhat remarkable that both the period of upheaval and the period of formation of these Charnwood rocks should be still the subjects of much dispute, notwithstanding the considerable amount of attention which they have received from geologists. Respecting the period of upheaval, it may be gathered, from the statements of Mr. Plant and Mr. Molyneux, that both these gentlemen believe it to have been *post*-Carboniferous; Mr. Molyneux especially expressing himself to the effect that it was the prolongation of the Pennine axis which had "broken the back of the coal." It had been Mr. Plant's intention to have given a fuller exposition of his views on this point from the summit of Bardon Hill. Writing subsequently, he says: "The age of the anticlinal has been a matter of dispute ever since geology was a science; my opinion, after nearly thirty years' study of it, is that it is *post*-Carboniferous. Professor Hull says it is *pre*-Carboniferous, and that the mountain limestone of Grace-Dieu 'lies unconformably on the upturned edges of these Cambrian rocks. The question is one of immense significance, *viz.*, the existence, or non-existence, of a coal-field to the east and south-east of Charnwood." On the faith of this more sanguine view of the question

a boring through the Keuper marls is being executed close to the town of Leicester,* at a spot not far from the well-known Rhætic section, which has been worked with such success by Mr. W. J. Harrison. Should coal be found there, the views of Hull would scarcely seem to be sustained in that quarter. That geologist was of opinion that an old land surface† existed during the Carboniferous period extending quite across England, from Wales to the Wash, and that the Charnwood hills are portions of that old land surface, in a hollow or bay of which what are now the Leicestershire Coal measures were deposited.‡ It is quite possible that this may have been so, and yet that this old land surface felt the effect of those elevatory forces which, acting on N. and S. or Pennine lines, have tilted the Coal measures in post-Permian times. This would serve to explain why local geologists view the Charnwood anticlinal as post-Carboniferous; but that by no means takes away the possibility of its having been an old land surface during Carboniferous times, and that the Leicestershire coal-field is an original basis of deposit, terminated at its eastern margin by pre-existing land surfaces. The period and mode of formation of the Charnwood rocks, is equally a subject of dispute, though, as the issue has no economic importance, these are matters of purely geological interest. By the Survey, they are called Cambrian, because, as Professor Ramsay told Mr. Plant, there were no sedimentary deposits of older date then known. Since then, Mr. Plant has suggested (Geol. Mag., 1865, p. 233) that, from Mur-

* Mr. Harrison, writing Nov. 12th, 1875, says: "The boring has, it is stated in last week's local papers, reached the New Red Sandstone; they are down nearly 700 feet through red marl and clay, and have now reached a bed of sandstone. If this is the Upper Keuper Sandstone, it is overlaid by a much greater thickness of marl than farther west, where some 200 feet only are found above it."

† "Coalfields of Great Britain," 3rd ed., p. 464.

‡ "The known coal areas of England seem to have been deposited to the north and south of a tract of Carboniferous land surface, to which I have several times alluded under the term of the 'Barrier.' This tract of land appears to have extended from Wales, Shropshire, and Herefordshire, towards the east, along the southern margin of the South Staffordshire coal-field. The prolongation of this land surface may again be recognised in the Cambrian rocks of Charnwood Forest; and between this part of its range, and that of South Staffordshire and Worcestershire, there was probably a deep bay, stretching in a southerly direction, which was filled in by the prolongation of the Leicestershire coal-field." "Memoirs of the Geological Survey, Triassic and Permian Rocks of the Midland Counties," by Ed. Hull, M.A. F.R.S., p. 109.

chison's own data, they ought to be called Laurentian. Hence, it appears, there is a general idea of their being very old indeed; and, as they are only found in company with very much more recent rocks, we have nothing to prove the contrary. Lithologically, the resemblance of some of the slates and agglomerates to the volcanic rocks of Cumberland, has been already noted; thus they may ultimately turn out to be Silurians of the same age as those beds. (See p. 473.) The mode of formation is also a subject of dispute, and Professor Ansted has taken extremely metamorphic views. He appears to consider that one great deposit of marls, clays, and sand was, in very early times, upon an axis of depression then existing over Western Europe, lowered within the scope of metamorphic action, and then brought up again, on an axis of elevation, itself one of the most ancient in Europe. It is very difficult to avoid believing that the syenites of Groby and other places are true igneous rocks, although they may have undergone a considerable amount of alteration due to chemical changes, acting through long periods of time; but this is very different from what is usually understood by metamorphism.

After enjoying Mr. Everard's hospitality this section of the party had a rainy walk to Coalville, where they joined the rest, and all proceeded by rail to Gresley, a station on the Moira coal-field* some distance to the west of Ashby-de-la-Zouch. From Gresley, the party walked down the line about a mile towards the Coton Park and Linton colliery—passing on the way a section of the lower portion of the Pebble beds of the Bunter.

This is an instance of a shaft being sunk through beds of Triassic age, in order to reach the rich seams of the Carboniferous series of Moira, which are here at a very moderate distance from the surface. The main seam is upwards of fourteen feet thick, and is mostly good coal, with no gas. Whilst awaiting the arrival of Mr. Molyneux some of the party amused themselves by inspecting the "gobfires," which had converted the rubbish-heap of the pit into a little volcano. Shovelsfull of sulphur might have been taken away from here before the rain. Many "needles" and "flowers" of sulphur were still to be had. There was also a considerable quantity of

* For information about the Leicestershire coal-field see "Hull's Coal-fields of Great Britain," page 225 *et seq.*

ferrous sulphate, likewise the result of the oxidation of pyrites, which is plentiful in the smutty clod; crystals of salt are not uncommon.

After partaking of the hospitality of the Company the party descended into the workings, which are remarkably clean and dry. These galleries—lofty indeed for a coal-mine—are all hewn out of the coal; the workings have a face of ten feet. The roof contains numerous compressed plant remains, mostly *Sigillaria*.

In the evening the members availed themselves of the opportunity of inspecting the Leicester Museum.

Wednesday.—On this day Barrow lime beds were set down for a visit. The train from Leicester was taken, which soon brought the party to the Lias beds. Here the various operations of removing, lifting, burning, and grinding the limestone were witnessed. This was succeeded by a search for fossils. Ammonite casts and *Pectens* were very abundant. From Barrow, Mountsorrel was soon reached, where, under the guidance of Mr. Edmunds, a minute inspection of the Mountsorrel Granite Company's extensive operations was carried out. Luncheon was here provided. The company then made a tour of inspection of the hill, where the remarkable glacial action was pointed out. A discussion took place as to the origin of the drift found at the side of the hill. The fact of Liassic and Oolitic fossils being common in it is conclusive against its being a true moraine, though it partakes more or less of a moraine character. A trap dyke on the flank of the hill, about six inches in width, and extending for several hundred yards, and composed of pure felsite, was next noticed. The members carried off specimens of this intrusive igneous rock. Simpson's quarry was then visited. This place has a historic interest, it being that visited by Professor Airy (Astronomer Royal), the late Professor Whewell, and Professor Sedgwick. These found a trap dyke of greenstone in 1834, but as the quarry has been worked that has probably become obliterated, no trace of it being now visible. The gneissic rocks were next visited, after which the company returned to Sileby station, whence most of them proceeded to London.*

* See also W. J. Harrison, "On the Geology of Leicestershire," Proc. vol. v. p. 126.

FIG. 179.—WEST LEICESTERSHIRE. GENERAL SECTION.

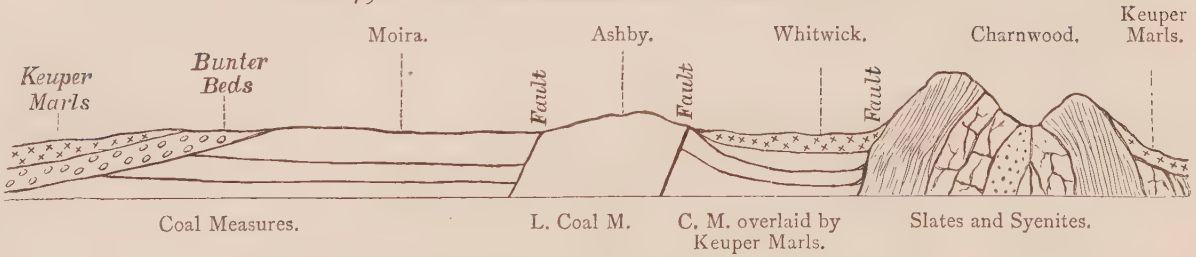

FIG 180.—EAST LEICESTERSHIRE GENERAL SECTION.

EXCURSION TO LEICESTERSHIRE.

WHIT MONDAY, MAY 21ST, 1877, AND FOLLOWING DAY.

Directors—WILLIAM J. HARRISON, Rev. T. G. BONNEY, F.R.S., and Rev. E. HILL, F.G.S.

(*Report by* W. J. HARRISON.)

(*Proc. Vol.* v. *p.* 142.)

THE LIAS AND OOLITES OF EAST LEICESTERSHIRE.

FIRST DAY.—The London detachment left St. Pancras for Market Harborough. The party proceeded to examine the sections exposed in the brickyards close to the station. Here the junction of the Upper and Middle Lias is exposed, showing—

		ft.	in.
Upper Lias.	1. Soil . . . . . 2 ft. to	3	0
	2. Clay, with *Ammonites communis* and *Belemnites compressus*	3	0
	3. Brownish band of ironstone . . .	0	9
	4. Soft, irony, sandy bed, containing great numbers of *Ammonites serpentinus*, *A. bifrons*, *A. Holandrei*, and *Belemnites compressus* .	2	0
	5. Bluish Clays	9	0
Middle Lias.	6. The Marlstone Rock bed, a micaceous ferruginous sandstone, with *Ammonites margaritatus*, *Belemnites paxillosus*, *Cardium truncatum*, and *Avicula novemcostæ* .	1	3
	7. Clay	3	0
	8. Band of "Skerry," with ironstone nodules, containing specular iron and *Avicula cygnipes*.	0	6
	9. Brown Clay	3	0
	10. Bluish Clays	8	0
	11. "Skerry"	1	0
	12. Clay	3	0

Most of the above-named fossils were obtained by the party, who then entered carriages which were in waiting, and proceeded eastwards along the valley of the River Welland to Medbourne, a village situated in a valley between the two Oolitic outliers of Slawston Hill and Neville Holt. Dismounting at the foot of the

latter eminence, they passed along the cutting in course of construction for the Midland Railway's new line from Melton Mowbray to Medbourne. It was the great object of the day's work to examine the fine sections exhibited along the line, and every facility was afforded for this purpose by the kindness of the engineers in charge, and Messrs Logan and Hemingway, the contractors. The cutting at the west foot of Neville Holt Hill displayed an admirable and fresh section of a fault, running E. and W., and throwing down the beds on the north some ten or twelve feet, so as to bring the blue clays and *serpentinus* beds of the Upper Lias on a level with the Marlstone Rock bed on the south. At the south end of the cutting the Fish and Insect limestones of the Upper Lias were noted, with the Paper-shales above them. *Ammonites annulatus* was very numerous here.

In consequence of the wet state of the ground, the party ascended the hill directly from the western side instead of walking round to the south. Passing over a long slope of Upper Lias clay, the junction with the Northampton Sand was found to be marked by numerous springs. This latter bed, also known as the Lower Estuarine series, forms here the very base of the Inferior Oolite. It is finely shown in the ironstone quarries on the southern brow of the hill, which were largely worked for a short time, furnaces being also erected close by. The ore was not, however, found sufficiently rich to pay, and the quarries were closed in 1875. The Northampton Sand is here about twenty feet thick. The upper portion is brown, friable, and marked by dark-brown bands, often concentric, which are very rich in iron. Lower down it passes into a hard, ferruginous sandstone, the blocks being usually blue-hearted. Several fine specimens of *Terebratula sub-maxillata* were found here, with *Rhynchonella cynocephala*, an *Ostrea*, and *Pecten lens*. Fragments of wood are common, and in patches of whitish sands many plant markings are visible. Returning from this point the party passed along a narrow cutting, in which, and in the neighbouring allotments, thin fissile limestones were seen, representing the Collyweston Slate. On the very top of Neville Holt quarries were examined in the Lincolnshire Oolite Limestone, which is here full of corals.

From the hill-top a splendid view of the surrounding district was obtained, and Mr. Harrison pointed out that the outlying Oolitic strata which constitute the hill had been preserved by a fault running east and west along the northern foot, throwing down the beds to the south. To the south and east the view

extended over the valley of the Welland to the main outcrop of the Inferior Oolites, which form there a low, yet well-marked range of hills, the northern termination of which is known as the "Cliffe" of Lincolnshire. Northward and westward are devious valleys formed by streams cutting through the Marlstone Rock bed of the Middle Lias. Descending the hill the carriages were reached and a start was made northward, following very nearly the new line of railway. In this way the gradual thickening of the "Rock bed" was well observed, as the route lay nearly in accordance with its strike.

Time compelled the omission of the Slawston cutting, and, passing through Hallaton, the next halt was made at the village of East Norton. A tunnel was being driven through the hills S.E. of the village, the Rock bed being the floor. In the open cutting north of the tunnel the Upper Lias Clays were finely exposed for fifty or sixty feet in depth. The portion here seen consists of dark-blue pyritous clays, weathering to a light colour when exposed to the atmosphere, and then containing much selenite, with bands and concentric balls of hydrated pyroxide of iron, formed by the decomposition of nodules of iron pyrites. The same beds had been seen by the party, *en passant*, in the brickyard at Moor Hill Lodge, just before entering East Norton. These unfossiliferous beds rest, in Leicestershire, upon clays full of *Ammonites communis* and are surmounted by clays with layers of septaria containing *Leda ovum*. At this point the Drift was well seen overlying the clays. It contained many well-striated boulders, chiefly of Carboniferous Limestone and Millstone Grit, with great numbers of the common Liassic fossil, *Gryphea incurva*. Passing northward through Lodington several of the railway bridges in course of construction were examined, the material being the Marlstone Rock bed. The stone was of a greenish-blue tint, and contained innumerable quantities of two brachiopods, *Terebratula punctata* and *Rhynchonella tetrahedra*. *Belemnites paxillosus* and *B. clavatus* were also abundant. These fossils usually contained in their interior a mass of crystallized carbonate of lime, and they formed a natural decoration to the stonework.

On reaching Robin-a-Tiptoes Hill (755 feet high) time did not permit of the ascent being made. This very characteristic, flat-topped hill stands on a plateau of marlstone, the long slope is formed of Upper Lias clay, and it is capped by Northampton sand. Whadbarrow Hill to the north, and Barrow Hill on the east, are similar outliers. The conspicuous conical hill due west

is named Colborough and has a well-wooded summit. Dense woods in this neighbourhood usually mark thick deposits of Boulder Clay, such land being difficult to bring under cultivation. On the west side of Robin-a-Tiptoes a deep railway cutting was examined, which afforded a magnificent section of the Marlstone rock bed, here nearly twenty feet thick. It was interesting to note the passage downwards from friable brownish sandstone (due to weathering influences) to blue-hearted masses, and finally to beds of dense blue ferruginous sandstone. The iron in the latter exists in the state of carbonate, but under the influence of air and water it becomes changed into the peroxide, which is of a brownish hue. Several good fossils were obtained in this cutting, including *Pecten æquivalvis*, *P. dentatus*, *P. liasianus*, *Pentacrinus lævis*, &c., besides the common ones already mentioned. A large fragment of wood, apparently of a coniferous tree, was also examined.

After tea in the village of Tilton a westerly course was taken past Billesdon Coplow—a rounded, hummocky mass, which is an outlier of Marlstone, and is celebrated in hunting story—through the village of Billesdon to Leicester. The Bell Hotel, in Humberstone Gate, had been selected as head-quarters.

Charnwood Forest, the Monastery, and Mountsorrel.

Second Day.—Starting in carriages at 9.30 a.m., the party drove to the Syenite quarries at Groby. Here the Keuper Marl is seen to dip away on all sides (quaquaversal dip), from the central boss of syenite, which must have formed an island, or shoal, in the Triassic sea. At a point about a mile further on, in Steward's Hay Wood, the Rev. T. G. Bonney and the Rev. E. Hill pointed out an interesting junction of the slates and syenites, clearly proving the latter to be intrusive. Passing the syenite knoll of Markfield, the interesting rocks known as the "Altar Stones" were examined.

After luncheon the most interesting region of altered rock, which extends from Green Hill past Peddar Tor, was closely examined. The Rev. E. Hill had given to each member an outline map, on which the character, dip, &c., of the rocks in the neighbourhood of Peddar Tor were laid down. The whole ridge appears to be composed of volcanic agglomerates and ashes of varying fineness, having a felspathic base, in which crystals of felspar, often with worn edges, and blebs of quartz are visible. The felspar crystals may possibly have been ejected from volcanic

vents in their present state, but the quartz appears to be of subsequent formation. Many of the members went over the Monastery of St. Bernard, which is situated in the midst of this wild and rocky region, and which belongs to the Cistercian Order. It was built in 1835, from designs furnished by the elder Pugin.

Crossing the anticlinal valley, and leaving Whittle Hill on the left, the road was taken which circles round the north side of Beacon Hill. From this point a ridge stretches to the village of Woodhouse Eaves, along which the party proceeded to walk, while the carriages went round to meet them in the village. The rocks of the ridge (known as the Hanging Stones of Woodhouse Eaves) were found to be indurated slates, agglomerates, and pebble beds. In one little quarry near Pocket Gate some circular markings were found which gave rise to much discussion. They lie on the bedding-planes, which here coincide with the cleavage, and consist of alternate ridge and furrow. The largest measures twelve inches by ten; in the opinion of Prof. Bonney they are concretionary. As to the age of the rocks of the Charnwood Forest region, the Directors appeared unanimous in assigning them to the Silurian system. They are coloured as Cambrian by the Geological Survey, whilst by some geologists they are considered to be Laurentian. In the absence of fossil evidence and that afforded by superposition, the question is at best but a balance of probabilities.

Thence driving quickly through Woodhouse and Quorndon, the famous granite quarries at Mountsorrel were reached at 5 p.m. and Mr. Hambly, the managing director, showed the way over the works. The working "face" is nearly half a mile in length, and about six hundred men and boys are usually employed. The stone contains pink and white felspar, bottle-green hornblende, and a little mica. The presence of the hornblende entitles the rock to be called a hornblendic granite. The face forms a conspicuous object from the Midland main line between Barrow and Sileby; but the old windmill which formerly crowned the spot, and was a noted landmark, has lately been removed, owing to the progress of the works. In a side cutting at the northern end the relations of the Red Marl to the granite are admirably seen. The marls here are much ripple-marked, and contain large fragments of granite. The slope of the hill shows the granite well polished and striated—the effect probably of both sea and ice action. *Molybdenite* occurs here, and there is a large

basaltic dyke crossing the face, which subsequently seems to have been broken up, as it is in a brecciated and rubbly state. After witnessing the breaking up of some large masses of granite by means of charges of powder and dynamite the party ascended the hill. On the top there is a very typical felsite dyke, seven or eight inches thick, which cuts sharply through the granite. But a hasty departure had to be made, and, driving rapidly, Leicester was reached about 7 p.m.

Thus ended the Whitsuntide Excursion of 1877. On the first day it included about twenty-five miles, and on the second day about thirty-five miles of driving and walking.

[*Charnwood Forest* was also the scene of the Whitsuntide excursion, 1888, the Rev. Edwin Hill and J. D. Paul being Directors. See Proc. Nov. 1888 (vol. x. p. 472).]

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New Ordnance Survey. Sheets 141, 142, 155, 156. 1*s* each.

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Harrison, Geology of Leicestershire and Rutland, 1877.

EXCURSION TO DERBYSHIRE.

MONDAY, JULY 22ND, 1877, AND FIVE FOLLOWING DAYS.

Directors—Rev. J. MAGENS MELLO, F.G.S., and ROOKE PENNINGTON, F.G.S.

(*Report by* the Rev. J. M. MELLO.)

(*Proc. Vol.* v. *p.* 186.)

THE members arrived by the mid-day train at Clay Cross, where they were received by Messrs. J. P. Jackson and C. Binns, and by the Rev. J. M. Mello. On arriving at the collieries of the Clay Cross Company, they were entertained at luncheon by the owners, after which they proceeded to inspect some of the coal-pits, in which the numerous and beautifully preserved fossil plants, ferns, lepidodendra, &c., and the mode of occurrence of the coal, and

the manner in which it was worked, created much interest. Attention was also called to the presence of an enormous sub-angular mass of Ganister rock in the clay, exposed close by in the receptacle that was being made for a new gasometer. At the offices of the Company a large series of beautiful fossils from the coal shales were placed at the disposal of the visitors. Subsequently the party drove to Chesterfield, *viâ* Milltown and Ashover, examining on the way the extensive lead-mines at the former place, and also during the journey the various members of the Carboniferous or Mountain Limestone, as it is usually called in Derbyshire, the Yoredale series and the Millstone Grit, as they successively cropped out. The fine quarries in the "Rough Rock" or "First Grit," at Stannedge, attracted considerable attention, the rock here being very massive and magnificently jointed.

On Tuesday morning the Association left Chesterfield in carriages, and drove to Cresswell, where the important bone caves lately explored and described by the Rev. J. M. Mello and Profs. G. Busk and W. Boyd Dawkins were visited. The Rev. J. M. Mello explained the manner in which the various remains had occurred in the caves, and called attention to the great geological importance of the discoveries made there, which in some respects are unique; a distinct succession of beds containing evidences of the progress in civilisation of Palæolithic man having been observed in these caves, a succession represented with such distinctness in no other single cavern. An engraved bone was also found here, the first discovery of the sort in Great Britain, which correlates the old Derbyshire caves with those of France and Switzerland; another important discovery which had been made at Cresswell was a canine tooth of the strange sabre-toothed *Machærodus*. Several teeth of various animals and a few flint implements were found by members of the party among the *débris*. In the afternoon, after returning to Chesterfield, the geologists drove to Bakewell through Chatsworth Park.

On Wednesday the party left Bakewell to visit Miller's Dale and Buxton. At Miller's Dale the Toadstone and lead-mining operations were examined, and specimens of minerals obtained, galena, calamine, and calcite being the principal ones. In Tideswell Dale a curious bed of columnar clay was an object of interest: this, which was described in the Quart. Journ. Geol. Soc., vol. xxvi., 1870, p. 701, appears to be volcanic mud, baked into its present

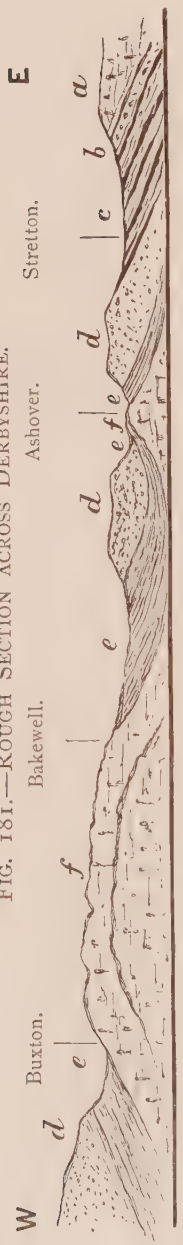

FIG. 181.—ROUGH SECTION ACROSS DERBYSHIRE.

a Permian.
b Lower Red Sandstone.
c Coal Measures.
d Millstone Grit.
e Yoredale Rocks.
f Mountain Limestone.

prismatic form by the heat of the overlying igneous rock, which here was seen to consist of an almost basaltic rock, a very dense and fine-grained dolerite, containing numerous concretionary balls, like volcanic bombs in shape. Dr. Maybury advocated the opinion that the prismatic clay was really the result of the decomposition of the toadstone, and not the result of mud subjected to its heat and pressure only. The Rev. J. M. Mello considered that analogy rather favoured the latter view, inasmuch as such red clays are frequently found interbedded with dolerites, and have been altered by their heat in some cases; also that the surface of the toadstone resting on the red clay is sharply defined from it, and is vesicular in character. It would also be difficult to account for the presence of the alumina in such abundance, it not being the prevailing mineral in the dolerite; and lastly it was often found that the clay in brickyards presented a precisely similar appearance to that in question.

From Miller's Dale, Chee Tor, a fine cliff of Carboniferous Limestone, was visited, and the gorge-like character of this part of the dale well seen. Some of the party walked from here to Buxton, where they were joined by the remainder, who preferred going by train. Poole's Hole, and the extensive Limestone quarries, were the objects of interest at Buxton. The cavern called Poole's Hole is too well known to need description; the museum attached to it contains a most nondescript assortment of curiosities, together with a few Romano-British antiquities, and

bones derived from the cavern itself, and it was felt to be a great pity that this cavern had not been systematically explored before its floor had been so much disturbed. On the way to the quarries the remarkable calcination of an extensive portion of the hillside above Poole's Hole was noticed, and as no traces of lime-kilns of modern construction were anywhere visible, and the huge calcined mounds were in many places overgrown with trees and shrubs, it was suggested, in the absence of any other information, that the Romans may have burnt lime there. The quarries were much admired, and the interesting effects of atmospheric denudation were well seen on the exposed upper surface of some of the beds.

On Thursday morning the party left Bakewell by train for Chapel-en-le-Frith, where Mr. Pennington joined the party, and all set off in carriages to Castleton, examining on the way the outcrop of the Yoredale Grits, and the swallow-holes along the line of junction between the Yoredale Shales and the Carboniferous Limestone. At Eldon Hill a pause was made, and the barrow on the summit was looked at. It had been opened some time previously by Mr. Pennington and Mr. John Tym, the well-known mineralogist at Castleton, and some remains of interest obtained, which were described by Mr. Pennington. At Eldon Hole, which was close at hand, he also gave an account of his somewhat adventurous descent into it in company with Mr. Tym, and he described it as an almost vertical fissure, expanding at the bottom into a fine cavern. On the way to Castleton another pause was made at the Windy Knoll quarry, when Mr. Pennington gave a short sketch of his exploration of a fissure in a swallow-hole, in which a large assemblage of bison, reindeer, bear and wolf bones were found. It had apparently been a drinking-place, where these animals, in the course of their annual migrations across the country, had got engulfed. At this quarry some of the party entered a small swallow-hole or cave, which pierces the hill close by; and others secured specimens of *Elaterite* or elastic bitumen, a rare mineral which occurs here in some abundance, and also of "Blue John," and picked up many small fragments of the bones of some of the animals previously mentioned.

Leaving Windy Knoll, the Blue John mine was entered, and on the slopes of Trecliff some of the party were able to glance at the Odin mine, and to obtain some good Carboniferous Limestone fossils. At Castleton the admirably arranged Castleton Museum was visited, Mr. Pennington explaining its contents. The geological collection here was most instructive, containing typical

fossils from all the formations, and including a remarkably fine series of bones and implements, illustrative of the lately finished explorations of Cresswell Caves and Windy Knoll, as well as specimens from other localities. On leaving the museum, the entrance to the great Peak Cavern was visited, and then the party went to the Speedwell mine, which was illuminated by Mr. Tym.

On Friday some of the hardest work during the excursion was done. The majority of those present walked by Back Tor, Edale and Grindsbrook Clough, over Kinderscout to the Snake Inn. The weather, which at first looked threatening, proved delightful, and the magnificent scenery and instructive geological phenomena rendered the walk over this wildest part of Derbyshire most enjoyable. The track followed led from the Carboniferous Limestone border at Castleton, over the Yoredale Shales of the valley: these, as the ascent was made up the slopes of Back Tor, were seen to be overlaid by the Yoredale Sandstones and Grits, which often form fine escarpments, owing to the slips which take place through the denudation of the Shales; such slips were well seen on the banks of Mam Tor, the whole hillside having fallen away, and carried with it part of a British camp, traces of which were seen on the summit. The Yoredale Shales were again crossed in Edale, where they are covered by a very considerable thickness of coarse river-drift. Passing up Grindsbrook, and ascending Kinderscout, the Yoredale Grits were seen to be capped by the lowest member of the Millstone Grit series, the Kinderscout Grit, here a conglomerate containing numerous rounded pebbles of white quartz. The summit of Kinderscout presented some fine outcrops of weathered rock, and it was interesting to observe the contrast between the mode of weathering shown by the Kinderscout Grit and the more even nature of the escarpments formed by the other members of the Grit series, especially the "Third Grit." At the Snake Inn a halt was made for lunch, after which the great landslips in the valley of the Alport were visited. The party ascended to the top of the Alport "Castle," a piece of exertion which well repaid the extra labour, the view obtained being very fine, and the full extent of the huge landslip which has separated the masses of Yoredale rocks, called the Tower and Castle, from the main body of the moorland, being well seen. From the Alport a return was made in carriages by the valley of the Derwent, through Hathersage and Calver to Bakewell.

On Saturday the concluding work of the week was done. The Rowtor and Cratcliff rocks and outlines of Kinderscout Grit were

examined on the way to Matlock. At the Cratcliff rocks there is a curious little chapel, with a crucifix sculptured out of the solid rock, which may be of Saxon age. Matlock was only reached in time for a hasty visit to the Tufa quarry, and the great fissure in the High Tor. The tufa or calc-tuff, was seen to be deposited in great thickness, the accumulation still continuing, the constant evaporation of the lime-charged water adding day by day to the rock mass; recent snail shells, sticks, mosses, grass and other objects were found buried in and encrusted by the lime. The fissure in the High Tor was entered, and found to be very deep and narrow, and should a stream of water ever again get access to it, it would probably lead to the severance of the present face of the Tor and an enlargement of the ravine through which the river now flows, and which was formed, in all probability, in past ages along a similar fissure.

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NOTTINGHAMSHIRE AND LINCOLNSHIRE.

EXCURSION TO GRANTHAM AND NOTTINGHAM.

Easter Monday, April 17, 1876, and Following Day.

Directors—The Rev. Dr. A. Irving, F.G.S., and W. H. Holloway, F.G.S.

(*Report by* Dr. A. Irving.)

(*Proc.* vol. iv. p. 491.)

On the way by train from Peterborough to Great Ponton glimpses were obtained of most of the Lower Oolite series. At the former place the Cornbrash is seen in the bank at the side of the station

premises, and its exposure extends thence nearly two miles along the line towards Essendine. At the Casewick cutting is a fresh-water gravelly deposit, containing fresh-water shells and fossils derived from the Oxford Clay. The Cornbrash is seen at the bottom of the cutting, and again in the Banthorpe cutting. On leaving Essendine station the Great Oolite limestone is seen overlying the clays of the Upper Estuarine series. In the Dane's Hill cutting a slight synclinal curvature of the strata has exposed :—

1. Cornbrash (a little on the top near the north end).
2. Great Oolite Clay.
3. Great Oolite Limestone (two very hard distinct bands).
4. Upper Estuarine series.
5. Inferior (Lincolnshire) Oolite, reached at the south end.

From this place to Little Bytham, cuttings occur in Lincolnshire Oolite, with clays of the Upper Estuarine series occasionally overlying it; and from there to Corby these ferruginous sands, with frequent false-bedding, are very well exposed in a number of cuttings. From Corby to Great Ponton we have first a small cutting in the Great Oolite limestone; next a long cutting through Boulder Clay; then (leading to the tunnel) a cutting in which numerous blocks of limestone are seen jutting out of the Boulder Clay. On leaving the tunnel the Boulder Clay is still seen resting on the eroded surface of the limestone not far from Ponton.

Work commenced in the Great Ponton cutting. The beds exposed

FIG. 182.—SECTION ALONG THE G. N. RAILWAY FROM NOTTINGHAM TO LITTLE PONTON BEYOND GRANTHAM.

belong to the upper part of the Lincolnshire Oolite. The section may be roughly estimated by the following tabulated statement :—

1.	Rubbly Oolite	5 feet.
2.	Eight to ten beds of Shelly Oolite (in some parts soft), very fossiliferous, with five zones of *Terebratula* and *Lima*, in various stages of growth	15 feet.
3.	Soft Marl, containing Oysters in abundance at the north end, dividing and becoming thinly laminated towards the south . .	4 in. to 1 foot.
4.	Marly Rock, with Corals, *Nerinæa* and *Turbo*, somewhat irregular . . .	2 feet.
5.	Coarse shelly Oolite and Freestone . .	15 feet.

Owing to the recent widening of the cutting unusual facilities were offered for examining this section and procuring fossils. The party proceeded to another section in the same formation, which has been formed by the Little Ponton cutting. The courtesy of the Great Northern Railway Company deserves special acknowledgment. At Little Ponton the cutting is much deeper than that at Great Ponton, and (the strata lying in both cases nearly horizontally) a greater range of beds is exposed. At the former place, too, they are much thicker than at the latter, more massively bedded, but much less fossiliferous. They are much disturbed and broken in one or two places, the numerous fissures resulting being in many cases lined with stalagmite and other forms of carbonate of lime. The nature of the beds examined in this section may be seen from the following (in descending order) :—

1.	Rubbly Oolite composed of "Rag" and very comminuted Shelly beds, with compact Shelly beds, some "pisolitic" . .	15 feet.
2.	Thin band of Slaty Clay	2 to 3 inches.
3.	Compact Marly and Shelly Rock, with *Lucina*, *Pinna*, *Ostrea*, *Trichites*, and Corals	5 feet.
4.	Marly Oolitic Rock, containing *Gervillia acuta*	5½ feet.
5.	Compact Marly Rock, with few Oolitic Grains	1 foot.
6.	Thin bed of Clay	2 to 3 inches.
7.	Coarse-grained Oolitic Rock . . .	6 feet.
8.	Stratified Grey Sandy Clay . . .	1½ feet.

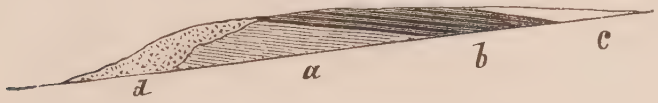
9.	Marly Oolite full of small Pectens . .	6 inches.
10.	Compact Marly and Sandy Rock, with *Gervillia acuta* and *Trigonia Phillipsi* .	$3\frac{1}{2}$ feet.
11.	Ferruginous Sandy Oolite, with shells in fragments, forming the base of the series known as Lincolnshire Limestone . .	1 foot.

This fine section, details of which were given by Mr. Holloway, furnished few perfect fossils.

The next halt was made at Grantham. Before passing over the railway to the south of this town the members drove along an elevated tract of country, formed by the ferruginous beds of the sands which mark the passage from the Upper Lias Clays to the Inferior Oolite. These beds may be seen in the cutting to the south of the bridge, capping the dark blue clays of the Upper Lias. They correspond with the lower series of the Northampton Sands, which have been very extensively worked of late years for iron ore. From the investigations of Samuel Sharp it appears that the Lincolnshire Limestones lie between two such series of ferruginous sands of estuarine origin; and that the thinning out of the limestone about Oundle allows the upper and lower series to coalesce, and so form the thick deposit of ferruginous ore which has made the country about Kettering and Wellingborough famous. From Grantham the route lay through Harlaxton and Denton to Croxton. On the way a fine view was obtained of the Lincolnshire "Cliff" (a worn-down escarpment of Lincolnshire Oolite), and two interesting road-sections were seen—the first exhibiting the junction between marlstone and clays of the Middle Lias series; the second the passage from the Upper Lias clays into the ferruginous sands described above.

At Croxton the party was met by Mr. W. Ingram, of the Duke of Rutland's estate, who pointed out various features of the surrounding country (including some remarkable terraces in the valley of the Devon) as the route was continued towards Belvoir Castle, where, through the liberality of his grace, luncheon was provided. On leaving, the party arrived, after about an hour's drive, at Elton station. The night was fast closing in by this time, and therefore a very imperfect examination only could be made of the Rhætic beds which are exposed here, and of the gypsum quarries which are worked in the uppermost beds of the Keuper series. So the first day ended by the party taking the train to Nottingham and being soon housed at the George Hotel.

FIG. 183.—SECTION BETWEEN NEWARK AND LEADINGHAM SHOWING RHÆTIC BEDS.



Line of road.

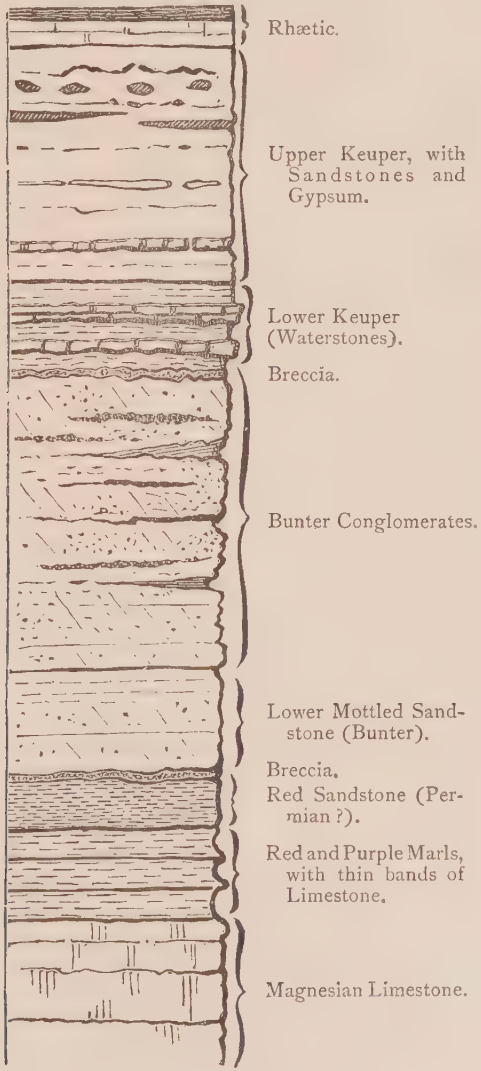
d. Rubbly mass of disturbed Paper Shales, mixed with fragments of Lias and Bunter pebbles.
c. Lower Lias.
b. Black Paper Shales.
a. Greenish and Grey Marls.

SECOND DAY (Tuesday).—Leaving Nottingham after paying a visit to the Nottingham Natural History Museum, the party visited the extensive stone quarries in the neighbourhood of Mansfield. The stone quarried hereabouts is not a pure dolomite or magnesian limestone, but consists of an admixture of (roughly speaking) about 45 per cent. of carbonate of lime and magnesia, with from 1 to 3 per cent. of oxide of iron and about 50 per cent. of silica. Specimens were procured of both the white and the red varieties of "Mansfield stone." The progress of the works at the quarries belonging to Mr. R. C. Lindley, of Eastwood (who had granted access to the members of the Association), had necessitated the removal of the Upper Permian Marls which overlie the Magnesian Limestone, and the members present had a good opportunity of viewing the uneven and eroded surface upon which these marls were deposited. After visiting Mansfield Woodhouse, and spending some time in examining the purer beds of dolomite which are quarried in that locality, and afford great facilities for studying "irregular bedding" and "oblique lamination" on an unusually large scale, the party found its way back to the Swan Hotel at Mansfield. Taking the train for Bulwell, they made their nearest way to Cinder Hill. In the brickyards belonging to Mr. C. Seeley the Upper Permian Marls which had been examined at Mansfield were again recognised, resting, as in the former instance, upon the Magnesian Limestone strata. The marls are succeeded (in ascending order) by rather hard deep-red sandstones, considered by the geological surveyors to be the highest member of the Permian system; a group of strata which some geologists prefer to consider as "Lower New Red Sandstone." There is no unconformity apparent between the highest bed of the "Permian" and the lowest bed of the Triassic series (Bunter) at

Cinder Hill; the only line of demarcation is a band of brecciated materials which varies in thickness from a few inches to about three feet. The breccia contains a variety of fragments, the greater number consisting of sub-angular pieces of limestone, much altered by the action of water, and somewhat dolomitic in character. They appear, however, to be derived, not from the Magnesian, but from the Carboniferous, Limestone, since many of them contain undoubted fragments of encrinites; and in the same breccia at Kimberley such fragments are even more frequently met with. This being so, there remains no evidence to be drawn from this breccia bed of any very great period of time having elapsed between its deposition and that of the Permian strata beneath it, to which it belongs just as much as to the Bunter above, passing as it does in some places underneath the uppermost layers of the sandstones of the Upper Permian. In the examination of this section much valuable assistance was obtained from Mr. E. Wilson, of Nottingham, to whose well-drawn sections the members of the party were much indebted. Much interest was added to the study of this section, and of the faults by which it is intersected, by a short lecture on the ground from Mr. George Fowler, the mining engineer of the colleries, who gave a clear and perfect explanation of the effect of the faults upon the Coal measures underneath the Permian at this place. The Magnesian Limestone is here faulted up against the Upper Permian and Bunter strata, and while these two formations are equally affected by the fault, the Coal measures below them have been proved by actual measurement to be dislocated by some sixty yards of vertical displacement more than the two series which here crop out at the surface. The enormous lapse of time which must be postulated to allow for sixty yards of displacement by the slow sliding of the strata against one another on opposite sides of the fault, before the Permian strata were deposited upon their denuded surface, is recorded also at Kimberley, where the base of the Permian system is now exposed in two new railway sections resting unconformably upon the planed-off edges of Coal measure shales and sandstone. Much interest appeared to be aroused by the evidence which the brickyard sections and those in the railway cutting not far distant afforded of the close relation that exists between the Permian strata and those of the Bunter above them. A walk from Cinder Hill along the new railway afforded opportunities for further study of the Bunter and so-called Permian strata, and in the cuttings which form the approaches to the tunnel at Watnall magnificent

sections were obtained. Here and near Kimberley, on the new Midland line, the Magnesian Limestone and Marl Slate series may be studied with unusual facility at present. They rest upon a base of exceedingly hard calcareous breccia, which forms the

FIG. 184.—GENERAL SECTION OF THE POIKILITIC STRATA OF THE NOTTINGHAM DISTRICT.



base of the Permians over a large district in Nottinghamshire. Very compact in texture, this breccia varies in thickness from one to three feet; and throughout the calcareous matrix numerous small angular fragments are dispersed, the origin of which cannot be easily determined. Small cavities, too, are of frequent occurrence, lined in some instances with calcite, in others with iron pyrites. Above it about twenty-five feet of Marl Slate occur, in which Mr. Wilson has found casts of *Axinus*; below it the Coal measure clays and shales, containing nodules of hæmatite, dip to the north-east, with an unconformity of about fifteen degrees.

A walk of about three miles brought the party to Ilkeston, where the train was taken for Nottingham and London.

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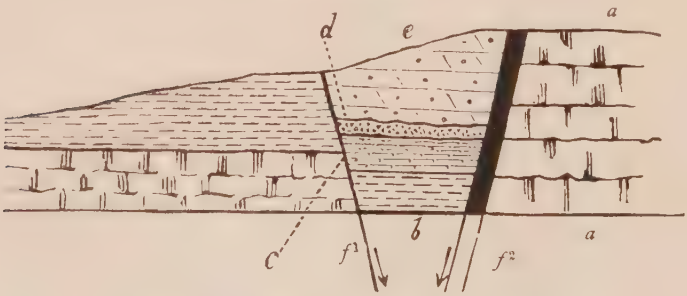
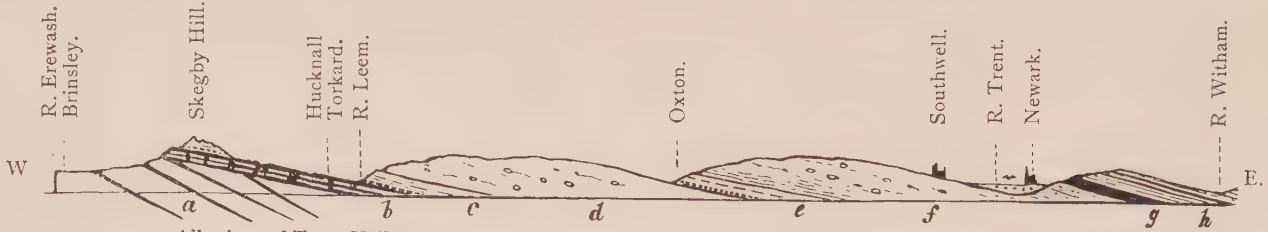
Fig. 185.—Section at Cinderhill Brickyard near Nottingham.



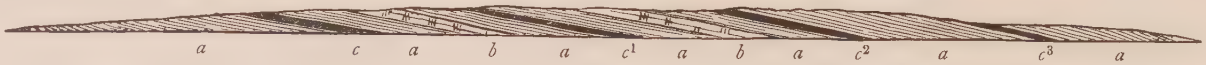
a. Magnesian Limestone.
b. Red and purple Marls with thin bands of Limestone.
c. "Permian" red Sandstones.
d. Breccia bed.
e. Lower Mottled Sandstone, much less coherent than *c.*
f^1. Fault, with downthrow to the right of ten feet.
f^2. Fault, with downthrow to the left of forty feet.

FIG. 186.—SECTION OF THE STRATA OF SOUTH NOTTINGHAMSHIRE, FROM THE EREWASH TO THE WITHAM.



Alluvium of Trent Valley.
h. Lower Lias Clays and Limestones.
g. Rhætic.
f. Upper Keuper.
e. Lower Keuper (Waterstones).
d. Bunter (Conglomerates).
c. Lower Bunter (Sandstones).
b. Permian.
a. Coal Measures (unconformable to Permian).

FIG. 187.—SECTION SHOWING COAL MEASURES IN THE RAILWAY CUTTING AT WOLLATON, NEAR NOTTINGHAM.



c^2, c^3. Coal seams of inferior quality.
c^1. "Soft" or "Comb" Coal (not worked).
c. "Top-hard" seam.
b. Thick bedded Sandstones.
a. Clunch and Shale.

EXCURSION TO LINCOLN.—April 14th and 15th, 1884.

Directors—W. H. Dalton, F.G.S., A. Strahan, F.G.S., and W. D. Carr.

(*Report by* W. D. Carr.)

(*Proc. Vol.* viii. *p.* 383.)

First Day.—The members taking part in this excursion arrived in Lincoln about midday on Easter Monday. The whole party moved through the city towards the north, ascending the steep slope of the Lincoln gorge, through which flows the River Witham; and at last, when reaching level ground, standing on the lower beds of the Lincolnshire Oolite. The first place visited was the brickyard of Messrs. Swan Brothers in the Upper Lias shale, which forms the slope beneath the Oolitic escarpment or cliff. Here a splendid section was seen, exposing all the beds from the Oolite to within twenty feet of the base of the Upper Lias, about eighty feet in all, seventy of which are in the Lias, which is here clearly definable into three well-marked zones, those of *Ammonites bifrons* (top zone), *A. communis*, and *A. serpentinus*. The top of each zone (except that of *A. bifrons*, which had been denuded before the Northampton beds were laid down) is well marked by a line of Septaria interbedded in a dark, coarse, calcareous shale, which, when struck with the hammer, exhibits a white streak. There are several of these bands in the two lower zones of the Upper Lias, but the two respectively separating the *A. serpentinus* zone from that of *A. communis*, and *A. communis* from that of *A. bifrons*, are thicker and harder than the others. The upper hard band (bringing in the zone of *A. communis*) stopped for a time the downward working of the clay diggers, who, on reaching it, made it form the floor of the pit, removing the upper beds completely to their outcrop within the limits of the pit, and then starting afresh lower down the slope till they encountered the next hard band, bringing in the zone of *A. serpentinus*. They then cut back the *A. communis* beds, forming in this way two distinct platforms, which exactly represent the upward limit of the zones of *A. communis* and *A. serpentinus*. The Lincoln Oolite at the top of this pit exhibits two distinct characters; first, that of a decidedly oolitic rock, and secondly, that of a dense, whitish, compact limestone, with a splintery fracture. This latter variety weathers rapidly, and is therefore rejected for all economic

purposes, not being even used for road metal. Underlying the limestones are found the ferruginous sands (ironstone) of the Northampton series, and farther back from the escarpment is a clay band twelve inches thick, separating the ironstone from the limestone above; but at the outcrop of the beds this clay is apparently squeezed out. At the base of the ironstone (which is only four feet thick at its outcrop, but quite fourteen feet a mile away across the strike) is the pebble bed, resting on an eroded surface of Lias clay. Among the pebbles are found rolled fragments of *A. bifrons*, and occasionally a contemporary fauna which is entirely marine. The upper thirty-one feet of the underlying clays (zone of *A. bifrons*) are nearly destitute of fossils; pieces of the characteristic ammonite and perhaps a few specimens of *Belemnites vulgaris* are the only species found. The latter has only been obtained near the junction with the zone below, if indeed it does not belong to it. The clay of these upper beds weathers into thin flakes (paper shales) and ultimately into a rather rusty-looking powder. As soon as the zone of *A. communis* is reached fossils occur abundantly. The greater number of species here found are restricted to the nine feet of shale which go to form this zone. Fossils also are abundant in the lower zone (that of *A. serpentinus*), which is brought in by one of the dark, gritty shales before mentioned, which, however, appears under very different aspects in the length of the pit, being in places a shale full of small shells, which is easily dissolved in water after being dried, elsewhere bound together as a semi-concretionary mass by iron pyrites, and again appearing as a good limestone a foot thick, extending for nearly twenty yards, but having in places a nodular character, as if the shale band enclosing a line of septaria had been converted into limestone. This limestone is extremely hard, and dark blue in colour, the joints weathering red. When the weathering is more advanced it becomes a bright yellow, and is apparently made up of little beside shelly *débris*. After this interesting pit had been well explored the members adjourned to Mr. Carr's house and viewed his collection of fossils. An advance was then made across the city and up the southern slope of the river-gorge, where another clay pit was entered, exhibiting a similar section to the pit first visited, with the addition of another forty feet below, twenty of which were in Upper Lias and twenty in Middle Lias. The base of Upper Lias is here formed of a band of limestone which weathers into very thin laminæ. The top bed of the Middle Lias (zone of *A. margaritatus*) consists

of very hard blue shale, with few joints, which makes it difficult to dig. It is usually cut away from beneath and brought down by "falling." After a short time spent in this pit a move was made towards another, about one mile distant, showing the junction of the Middle Lias (*A. margaritatus* zone) with the Lower (zone of *A. capricornus*). The base of Middle Lias is here formed by three bands of very ferruginous nodules of nearly uniform size. These are seen to dip into the escarpment towards the N.E. The marlstone rock bed (zone of *A. spinatus*) is at Lincoln entirely missing, though it is several feet thick near Leadenham, a few miles to the south, and it also comes in again at South Carlton, four miles north of Lincoln, and there forms a recognisable feature, throwing out springs at its junction with the clay below. The limestones forming the base of Upper Lias at the south cliff are proved by a shaft sunk at the pit of Messrs. Swan Brothers, on the north cliff, to have either altogether thinned out in the two miles intervening, or to have quite altered their character, a very hard, micaceous shale appearing on the same horizon at the latter place.

It was intended that the members should have visited a pit at Waddington, two miles south of the last section, and entirely in the zone of *A. capricornus*; but, there not being sufficient time, the party turned homeward, and catching the tram at Bracebridge returned to Lincoln.

Excursion to the Sections of Kimeridge Clay, Neocomian, Chalk, and Drift on the Louth and Lincoln Railway.

(*Report by* A. Strahan.)

Second Day.—A visit was first paid to a brick pit near South Willingham station, where was seen, below the tough blue clay used for bricks, a layer of great septarian stones. These occurred as slightly flattened spheres two to four feet in diameter, arranged along a nearly horizontal bedding plane. They consisted of a black, highly calcareous stone, intersected by numerous fissures lined with dog-tooth calcite crystals, and contained numerous fragments of fossils, chiefly *Ammonites biplex*. In the clay the impressions of small lamellibranchs were found crowded together on the surfaces of some of the shaly bands. About two feet below the septaria a little digging disclosed a bed of hard inflammable shale, locally known as "dice." Fragments of dice readily ignite when

dry, and blaze with an offensive odour ; it has been noticed also that the clay, when being burnt in the kiln, to a certain extent supports combustion, giving off fumes that are extremely prejudicial to vegetation. A large vertebra was found in this pit.

FIG. 188.—GEOLOGICAL MAP (WITHOUT DRIFT) OF THE NEIGHBOURHOOD OF SOUTH WILLINGHAM AND DONNINGTON.

(Reduced from the Map of the Geological Survey, by permission of the Director-General.)

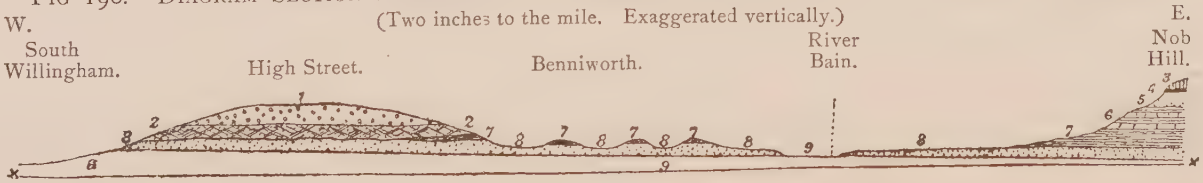
The party then proceeded to the Benniworth tunnel, the cutting at the west end of which shows intensely chalky Boulder Clay, resting nearly horizontally on fine buff sands and gravel. In the clay large scratched boulders of chalk and flint were observed. Passing through the tunnel the same superposition was observed at the east end, at nearly the same level, showing that the hill is probably a purely drift feature.

The cuttings near Benniworth Haven were then entered. The

FIG. 189.—SECTION FROM SWAN'S PIT (LINCOLN) TO SUDBROOK.
(An inch to a mile horizontal ; an inch to forty feet vertical.)

1, 2, and 3. Lower, Middle, and Upper Lias.
4. Lincolnshire Limestone.
5. Upper Estuarine series.
6. Great Oolite Limestone.
7. Great Oolite Clay.
8. Cornbrash.
} Lower Oolite.
9. Oxford Clay. Middle Oolite.
a. Messrs. Swan Bros.' Pit.

FIG 190.—DIAGRAM SECTION FROM SOUTH WILLINGHAM TO THE CHALK WOLDS NEAR DONNINGTON.
(Two inches to the mile. Exaggerated vertically.)



× Sea-level.
1. Boulder Clay.
2. Glacial Sand and Gravel.
3. Chalk.
4. Red Chalk.
5. Carstone.
6. Tealby Limestone.
7. Donnington Clay.
8. Spil-by Sandstone.
9. Kimeridge Clay.

line here passes through three small ridges of Spilsby Sandstone (Lower Neocomian), each capped by a shallow tongue of the iron ore which forms the base of the Donnington Clay (Middle Neocomian). A considerable search was made in this highly fossiliferous band,* which, however, has now been much affected by weathering. The junction of the iron ore and the Spilsby Sandstone is admirably shown, the former, brown, argillaceous, and crammed with oolitic grains of iron oxide, resting on soft white sand. The sand here, as is usually the case, contains irregular masses of friable sandstone, the brown colour of which indicates that the cementing material is iron oxide. Crossing the Bain a cutting was entered in the same bed, here in a harder form, and with many cavities forming external casts of *Pecten*. Concretionary structure of an interesting character was observed here, nuclei of a very hard grey calcareous sandstone, with numerous impressions of *Pecten orbicularis*, lying in a packing of perfectly loose ashy grey sand, round which, in large irregular curves, ran coatings of brown ferruginous sandstone. The mass of the rock outside was of the usual brown friable character, with scattered ferruginous lumps. It was observed that the lines of fossils were discernible through every layer of the concretionary masses, including the loose sand, showing that the sand particles retained their original position, though the intergranular cementing materials had been rearranged. The hard nuclei probably represented the original condition of the rock before it had been acted on by weather. They were about two feet long by one foot broad.

At Donnington station the line passes on to Donnington Clay (Middle Neocomian), and a brick pit in this sub-division was visited, showing a pale-blue clay with numerous specimens of *Exogyra sinuata* and phosphatic nodules, some of which contain crustacean remains.

The sections at the west end of the Withcall tunnel† were next visited, the upper part of the Middle Neocomian (Tealby Limestone) being not exposed in this neighbourhood. The cutting at the entrance to the tunnel shows—

		ft.	in.
Lower Chalk.	Nodular chalk with shale partings . .	13	6
	Hard, very gritty chalk, full of *Inoceramus* .	5	0
	Hard nodular grey chalk with *Terebratula biplicata*	1	6

* See H. Keeping, Quart. Journ. Geol. Soc., vol. xxxviii. pp. 239-244.

† Figured by Mr. Keeping, Quart. Journ. Geol. Soc., vol. xxxviii.

		ft.	in.
Red chalk 11 ft. 2 in.	Pale pink and yellow chalk, becoming red below	5	0
	Shaly parting	0	4
	Dark-red chalk	2	10
	Shaly parting	0	5
	Dark-red chalk with grit grains	1	6
	Red marl with grit grains, *Belemnites* abundant	1	0
	Carstone (base not seen)	30	0

Terebratula biplicata, *Belemnites minimus*, &c., were found in abundance in the lower part of the Red Chalk, and a fine specimen of a *Nautilus* (*simplex?*) was obtained. The Carstone was observed to be argillaceous in the upper part, with three lines of concretions formed in place a little below its top. Lower down there occurred a pebbly band containing numerous well-rolled phosphatic nodules, similar to those which occur in place in the Neocomian clays.

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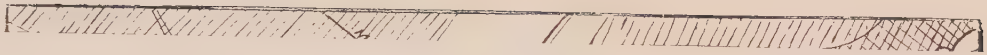


THE NORTHERN COUNTIES.

EXCURSION TO EAST YORKSHIRE.

MONDAY, JULY 19TH, 1875, AND FIVE FOLLOWING DAYS.

Directors—Sir CHARLES STRICKLAND, Bart., Professor JOHN MORRIS, F.G.S., C. FOX STRANGWAYS, F.G.S., JOHN W. WOODALL, and W. H. HUDLESTON, F.R.S.

(*Report by* W. H. HUDLESTON.)

(*Proc. Vol.* iv. *p.* 326.)

HAVING enjoyed the hospitality of the Yorkshire Philosophical Society, the party proceeded to inspect their Museum, where Mr. W. Reed pointed out the chief features, drawing especial attention to the collection of bones from the celebrated Kirkdale Cave, near Kirby Moorside, and to the interesting specimens from Bielbecks. Others of the party were shown the large collection of striated boulders derived from the mountains of the north, which have been recently discovered during the extensive excavations made for the new railway station; whilst a third section was conducted over the antiquarian department by the Rev. Canon Raine. The party proceeded to Whitby in the evening and took up quarters at the Crown Hotel.

On the following day the members visited the Whitby Museum, where Mr. Carruthers took the opportunity of examining some of the Oolitic plants in the collection. The bulk of the party inspected the fine exposure of Upper Lias on the south side of Whitby Harbour, together with the overlying Dogger and Lower Estuarine series of the Inferior Oolitic, remarkable for the great fossil mares' tails *(Equisetites columnare)* which it contains. Whilst the main party were examining the north part of the town and seeking admission to the Museum, some crossed the bridge to the older part of Whitby, with its steep and narrow streets. Mounting the hill-side by its long stone staircase, the visitors reached the fine old church, debased by modern windows, the elegant, though dilapidated, ancient cross, the abbey, beautiful

in ruin, and the old residence of the Cholmleys. About noon the majority proceeded by rail to Newtondale. At the railway station they were met by Sir Charles Strickland, Bart., and Mr. C. Fox Strangways. Through the kindness of the authorities of the North-eastern Railway Company the train was stopped near the "Needle's Eye." The remarkable gorge-like character of this part of Newtondale, hemmed in by mural precipices which spring from steeply-wooded slopes, could be only partially realised. These precipices consist of Kellaways Rock, which is here from seventy to eighty feet thick. Ages ago this gorge was celebrated for its breed of falcons, and Yewdale Scar, to judge from its appearance, would be a favourite nesting-place. It consists wholly of Kellaways Rock, resting immediately upon the Blue shales above the Cornbrash. At the base is a soft sand-rock, which weathers into a natural corridor; thence upwards is a series of horizontal slabs of natural masonry, alternating with layers of a softer material, and occasionally with rows of circular cavities, due to the dissolving out of sphæroidal masses more soluble than the rest of the rock. There are few more picturesque precipices in all these moorlands. The brownish-yellow tint of the rock contrasts well with the grey colour of the lichens, whilst the cliff-face itself is bristling with dwarf oak, birch, and holly. Arrived on the summit, the party, in the midst of a drenching shower, skirted the moorland edge of the precipitous escarpment in the direction of Levisham station. Before arriving there an old iron-mine in the Cornbrash, near Skelton Tower, was visited, and an extraordinary number of characteristic fossils obtained. This division of the party concluded the work of the day in the Pickering quarries, which, taken together, present a most remarkable and complete section of the Upper Calcareous Grit, Coralline Oolite, and passage beds connecting the latter with the Lower Calcareous Grit. At Pickering, whilst several of the party who came direct from Whitby hastened to the quarries of Coralline Oolite, some visited the grand old castle. Scarborough was reached in the evening.

On Wednesday the members drove to Peak Hall and descended the cliffs on the north side. Those who have ever had an opportunity of visiting this magnificent scene, wonderful alike for its impressive grandeur and for the lessons which it teaches, will be ready to admit that this great group of cliffs is unequalled in our island for its combination of impressive scenery with the advantage of geological sections. The fault which brings the

Middle Lias on a level with the Lower Estuarine beds of the Inferior Oolite is admirably seen about half-way down the cliff. At this point the general section on the eastern or downthrow side was explained, and the very remarkable difference of development which some of the beds undergo in those short distances pointed out.* The great feature of interest in this respect is the extraordinary importance of the passage beds between the Upper Lias and the Oolites. On first touching the beach, here terribly stony and difficult, the alum rock of the Upper Lias is seen in position, but as the beds are dipping rather fast in a south-east direction towards Blea Wyke Point higher beds succeed, containing a peculiar set of ammonites. Some very fine specimens of *Trigonia literata* were here found, and above this again a thick series of grey, sandy shales, from which specimens of *Ammonites striatulus* were obtained. The bay at Blea Wyke is hollowed out of these shales, above which occur the micaceous sands with *Lingula Beani*, which form the scar of that singular platform. At the corner the "Yellow sands" form the base of the cliff, and in the top of these is the *Terebratula* bed, which is separated from the true Dogger by a band of shale. Still proceeding south-east, as the bed dips rapidly, the whole of the Dogger, here about thirty-three feet thick, came within reach of the hammers of the party. The *Nerinæa* bed, towards the top, contains a splendid series of fossils: but these hard slabs of ironstone take much working. Viewed from below, this portion of the great Staintondale range is equally instructive, if less terrible, than that along the base of which the party had already scrambled. In ascending order there is a huge series of alternate shales and sandstones, indistinctly parted by the last feeble indications of the *Millepore* bed, which barely survives to crop out at Peak. In the upper part of the cliff is the great marine deposit of the Scarborough Limestone, capped by shales full of *Avicula*, and surmounted by a few feet of the Upper Estuarine beds.

On Thursday morning the members visited the Museum of the Scarborough Philosophical Society, which was thrown open to the members by the Council.

Mr. Carruthers gave a sketch of the plant-life of the Oolites of Yorkshire, as far as it had been determined from the remains found in the rocks. The cellular cryptogams were entirely absent, if two or three doubtful plants, which had been referred to Algæ,

* See Proc. Geol. Assoc., vol. iii. p. 294, *et seq.*

were excepted. The absence of cellular plants was due to conditions unfavourable to their preservation. Three groups of vascular cryptogams were represented in the rocks—the mares' tails by one or two species, the club mosses by some species, and the ferns by a large number of specimens, which had been made into more species in the books than had really been found in the rocks, because sufficient allowance had not been made for variation of form and venation which occurs in different fronds of the same species, or even in different parts of the frond. Fruit-bearing specimens of several species had been found, and though the form only was preserved as a thin layer of carbon it gave a more certain indication of the systematic position of the fossil than the venation only. The fruits indicated the presence of ferns, which could with fair reason be placed in existing groups of that order of plants. The rest of the ferns were separated into species from characters obtained from the venation—a most unsatisfactory basis for classification, but the only one generally available to the palæontologist. The higher flowering plants were represented in these rocks only by gymnosperms. No specimens had been found which could be referred to Monocotyledons or Dicotyledons. The conifers and cycads form a large portion of the plants preserved to us, yet it is certain that the record of them is very imperfect, for the stems and fruits belonging to the large series of the foliage of the cycads are absent. The separate scales of an *Araucaria* are not unfrequent in the shales, and they may belong to the foliage which is often associated with them, and which has been called *Brachyphyllum*. The fruit and foliage of another conifer is not unfrequent, and a leafy branch of a plant approaching the *Cryptomeria* of Japan has been found. Among the cycads two forms of cones have been detected, one nearly allied to the cones of existing species, except that the scales were scattered on the axis; and the other an anomalous form, which had been worked out by Professor Williamson, and was extinct. The speaker had established two genera for these plants, and recognising in some measure the labours of two Scarborough men who had done good service to geological science, he had named the first *Beania* and the second *Williamsonia*. It was very difficult to estimate the relation to living plants of the great variety of leaf forms belonging to the Cycadeæ which were found in these beds. When the fruit is found it will probably show that other types besides that of *Williamsonia* occurred in the Yorkshire Oolites.

Professor Morris reminded his audience that he had yesterday

enumerated the several formations seen in the cliffs of this neighbourhood, as far as they represented the Lower Oolitic beds, from the Lias upwards to the top of the Estuarine series, including the plant beds and coal seams of East Yorkshire. He had pointed out their various origin, whether estuarine or marine, and how far they were equivalent with the several members of the Lower Oolite of the south of England, viz., the Inferior Oolite, Fuller's Earth, Great Oolite, and Forest Marble. To-day, he said, they would see the strata higher in the Oolitic or Jurassic series. There would be the Cornbrash overlying the plant beds, a remarkably persistent though thin limestone, ranging from Yorkshire to Dorsetshire; this is overlaid by the *Avicula* shales, and the bed known as the Kellaways Rock succeeds. Here we find sandy beds, about eighty feet thick, with bands of peculiar fossils, near Scarborough, and thinning away to the south. The origin of the name (from Kellaways Bridge, in Wiltshire, one of the comparatively few places where it has been well exposed) was explained, and reference made to the "Father of English Geology," William Smith, the uncle and teacher of the late lamented John Phillips, who did so much for the geology of Yorkshire. After the Kellaways Rock had been deposited in relatively shallow and open waters, the sea of the period was invaded by mud brought from the cliffs, or from rivers, and this accumulated to the thickness of several hundred feet during a long period and over a large area, forming what is known as the Oxford Clay. Its equivalents are found under Moscow and in Northern India. The clay beds are here and elsewhere succeeded by the Coralline Oolite and its modifications of Coral Rag and Calcareous Grit, with their fossils of a somewhat Oxfordian character. How the succession of these alternating hard sandstones, limestones, soft shales and clays, when exposed on the cliffs, were worn away into sudden scarps and sloping taluses—as well shown by the profile of the Castle Hill—the Professor illustrated by a chalk diagram. The occurrence of Glacial clay, or Drift, in patches on the top of the Castle Hill was also noticed.

Professor Rupert Jones, having been asked to add a few words on the physical geology of the district, said he could not but be interested in the structure of the Castle Hill, as explained by Professor Morris, and when we sought for the proximate causes of the inclination of the strata we must have recourse to the hypothesis boldly, but yet philosophically, advanced by Dana and others, as to the crumpling of portions of the earth's crust, as one part sunk

and another remained at the level, and were crushed one against the other, giving rise to the mountains and areas of continents. The attention of the party was called to the flat-topped hills of the vicinity, and their relation to an old plain of marine denudation, and to the occurrence of hard horizontal strata resisting denudation, except where faults broke them up, and gave rise to many of the valleys, and often allowed the soft clays to be squeezed out, letting down the harder beds. The many subjects for thought and investigation comprehended in these hypotheses of undulation of the strata, plains of denudation, valley formation, and deposition of strata, were suggested for the consideration of the members.

Sir Charles Strickland remarked that there were some points in connection with the Liassic and Oolitic beds of this district which forced themselves upon his notice and which he might venture to indicate. One of these was the remarkable recurrence of analogous and even similar life forms in beds of different age, but possessed of similar mineral characters. This was particularly shown in the case of the Marlstone, Inferior Oolite, and Cornbrash, in which strong points of resemblance might be traced; and as regards the two latter, especially with an actual recurrence of many of the same species. In the Coralline Oolite, which he had made his especial study, he had come to the conclusion that there were two, or even three, very distinct sets of fossils. This peculiarity arose more from a difference of physical condition, affecting the life of the creatures, than from changes due to the lapse of time between beds of slightly different age. Thus the lower beds of this formation in Yorkshire generally consist of Oolitic limestone, and sometimes of compact or shelly limestone, the whole being generally devoid of actual coral. These beds contain a very different set of shells from the overlying Coral Rag, which, however, is irregularly distributed and unequally developed. The latter has a peculiar set of fossils, the remains of coral-haunting mollusca, &c., and is especially rich in finely-marked univalves, and in Echinodermata of many species, which, along with numerous other shells, may be extracted from the mineralised remains of these old coral reefs.

Mr. Fox Strangways remarked upon the importance of tracing the lines to which they had alluded, as by doing so we should be able ultimately to correlate the beds stratigraphically. In this district, which was marked by strong geological features, the stratigraphy of the interior was not always easy to read. The

system adopted by the Geological Survey was to commence upon the coast, where there are fine natural sections, and, having completed the survey of this portion, to make use of the knowledge so obtained for the mapping of the interior. He concluded by bearing testimony to the value of the labours of the late Professor Phillips in this direction.

Mr. Hudleston had very few observations to make by way of supplementing the remarks of the speakers. One point of interest might be noted as having an intimate connection with the question of the division between the Lower and Middle Oolites. At Scarborough this line might be drawn (palæontologically) rather above the middle of the Kellaways Rock, which is about eighty feet thick on the North Cliff. On this horizon there seems to be the first incoming of the Cephalopoda, so extremely plentiful in the top beds, thus marking the commencement of the Oxfordian fauna in this part of Yorkshire. Until this profusion of ammonites and belemnites sets in, there is not sufficient change in the other Mollusca to suggest the necessity for a separation into the Lower and Middle Oolites. The ammonites of the Kellaways Rock, of which there is a good show in this collection, present so many varieties of form, that fully thirty species had been described therefrom, though probably this number would have to be modified if existing views were to be carried out. There is a strong family likeness between some of the Kellaways Rock ammonites of Gristhorpe and some of those of the Oxford Clay and Lower Calcareous Grit of the coast. The next great palæontological group is the Corallian, here divisible, as Sir C. Strickland had observed, into two distinct sets. Since the Corallian can no more be viewed as a separate geological epoch, but merely as representing the coral and coral mud and sand areas (not synchronous in all parts) of the Oxford Kimeridgian sea, the name Corallian must be deemed a mere matter of convenience, not representing a formation in time. In this way, as regards time only, the fauna of the lower portion, or Coralline Oolite of Yorkshire might be assigned to the Oxfordian, whilst the upper portion, representing the *Cidaris florigemma* zone of Continental authors, may be assigned to the Kimeridgian.

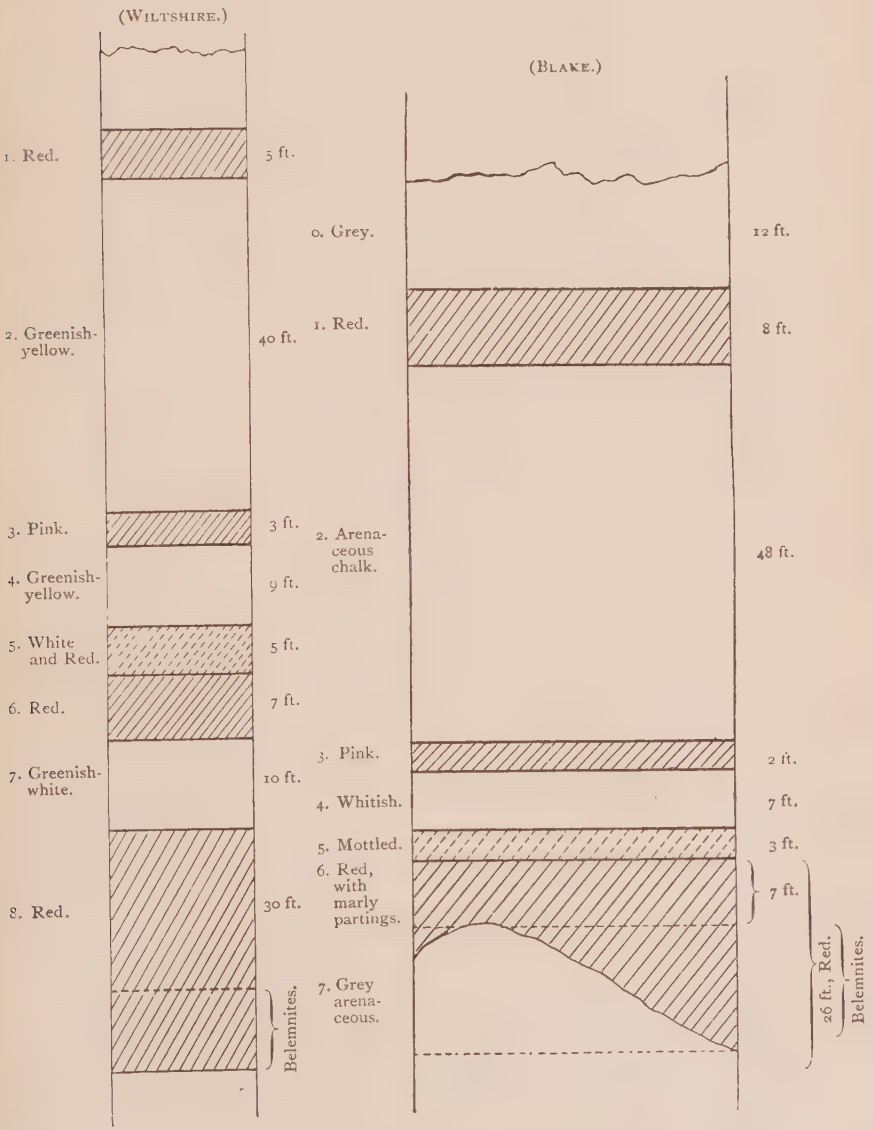
The weather having partially cleared on the afternoon of Thursday the party proceeded along the South sands, beyond the Spa, where the irregular and false-bedded sands of the Upper Estuarine series are seen to rest on the ironstones of the Scarborough Limestone. This latter group forms the Scar at White

Nab; here it is probably about twenty feet thick, having shrunk from fifty feet at Hundale, north of Scarborough. South of White Nab the formation decreases in importance, and in Gristhorpe Bay, where the party last saw it, four or five feet is about the total thickness. Crossing Carnelian Bay, the fault which brings the *Millepore* limestone against the Cornbrash at Ewe Nab, was noted, and the party, after scrambling over the enormous blocks of the former, found themselves in Cayton Bay. The fault near the waterworks, which brings the porous Calcareous Grit against a mass of drift clay, is probably the cause of that supply of water which is now used by the town of Scarborough. The grand semi-circular section beneath High Red Cliff next fixed the attention of the party. This serves to display the Middle Oolites, as the section at Peak does the Inferior Oolites. The sudden change of beds produced by the Red Cliff fault still further enhances the value of this section. It brings the Inferior Oolites in again, but the sedimentary beds are rapidly shrinking, and are packed into a much smaller space than further to the north. Thus, at Youn Point, the *Millepore* limestone, followed by a variable series containing the peculiar fossils of that horizon, is overlaid by the Carbonaceous series, or Middle Estuarine, which, besides much coaly matter, contains the celebrated plant-bed. Amongst some of the plant-shales a well-grown *Modiola cuneata* was found. The party ascended the slippery slopes of Gristhorpe Bay and returned to Scarborough by the road.

FIG. 191.—JUNCTION OF THE RED AND GREY BEDS OF CHALK AT SPEETON.

Friday was devoted to Filey Bay, and the first thing examined was the great mass of blue clay beneath the Chalk, known

FIG. 192.—SECTION OF THE BASE OF THE CHALK IN SPEETON CLIFF.



generally as Speeton Clay. Sir Charles Strickland brought home some fine specimens of *Ancyloceras*, and, on the whole, some of the members were pretty successful in finding characteristic fossils, such as *Belemnites jaculum*, *Gryphæa sinuata*, &c.

Professors Morris and Rupert Jones addressed the party. The former observed that the Speeton Clay comprised the Upper, Middle, and Lower Neocomian of Continental authors of which the Upper alone is represented, as the Lower Greensand, in southern England. The Lower beds are possibly in point of time the equivalents of the Wealden. Professor Rupert Jones could only express his thanks to Professor Morris for the masterly exposition of the relationship of the Neocomian formations of Yorkshire to those of the Continent as elucidated by Mr. Judd, and of the Wealden and other fresh-water and terrestrial formations to the marine deposits of that and the preceding periods. The sketch offered by the Professor of the old land once existing between the Neocomian sea of the Yorkshire area and that of the Brunswick region opened out many thoughts about the rivers and marshes of the old time, inhabited by enormous *Dinosauria*, and necessarily extensive, and rich with animal and vegetable life. Returning towards Filey, Mr. Strangways was able to point out a portion of the Kimeridge Clay just peeping above the sands. A visit to Filey Brigg completed the day's work. This well-known promontory presents a most remarkable section of the Lower Calcareous Grit, especially amongst the numerous caves on the north side of the Carr Naze. The singular forms which weathering brings out upon the various blocks were a source of endless speculation, and those remarkable concretions, which the irreverent youth of the place describe as fossil cannon-balls, gave rise to a discussion so sharp as almost to cause the members to forget that they had to deal both with tides and time-tables if they wished to leave the fascinating spot. This successful excursion was brought to a close by a dinner, given by Sir Charles Strickland, at the Pavilion Hotel, Scarborough.

On Saturday morning some of the members left early, but about a score accompanied Professor Morris and Mr. Hudleston round the Castle Hill, where the remarkable faulting of that area was explained, and the general section from the Kellaways Rock to the Coralline Oolite pointed out, and correlated, as far as the Lower Calcareous Grit was concerned, with that at Filey Brigg.

References.

Maps.—Ordnance Survey. Geological. Portions of sheets 94, 95, 96, 104.

New Ordnance Survey. Sheets 34, 35, 44, 54, 55. 1*s.* each.

Books.—For a full account of the Yorkshire Oolites see Mr. W. H. Hudleston, Proc., vol. iii. pp. 283-333; vol. iv. pp. 353-410; and vol. v. pp. 407-494. These papers are illustrated by maps, sections, and figures of characteristic fossils.

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EXCURSION TO THE WEST RIDING OF YORKSHIRE.

July 17th, 1882, and Five Following Days.

Directors—W. H. Hudleston, F.R.S., and J. W. Davis, F.G.S.

(*Report by* W. H. Hudleston.)*

(*Proc. Vol.* vii. *p.* 420.)

The West Riding of Yorkshire exceeds in extent either Devonshire or Lincolnshire, yet in spite of its size the Carboniferous Rocks alone form a very large percentage of its area. The district visited on this occasion was purely agricultural or pastoral, mostly the latter, not densely inhabited, and constituting an agreeable tract of hill-country which becomes mountainous towards the west. It forms part of a large block of older Carboniferous Rocks, which a series of east and west folds has brought to the surface between the Coal-fields of Durham and south Yorkshire, and is included within the Wapentakes (hundreds) of Claro and Staincross, the latter being nearly coincident with the archdeaconry of Craven.

Claro commences where the first roots of the Pennine chain spring out of the Vale of York. Hydrographically it comprises

* Some of the remarks made by Mr. Hudleston at the previous meeting are incorporated with this report, especially in connection with the geology of Harrogate and Knaresborough.

the whole of the basin of the Nidd, together with small portions of the Ure on the north and of the Wharfe on the south. Harrogate, with nearly 10,000 inhabitants, is the largest town, but Knaresborough must be regarded as its historic capital. Excepting strips of Trias and Permian on the east, almost the whole of Claro is on Millstone Grit, in parts covered by Drift. The surface ranges from 100 feet to 2,200 feet above sea-level, and contains a considerable proportion of indifferent land, some of which, however, forms the best grouse ground in the county. There are wide upland plateaux with valleys of moderate slope; the hills never attain to the dignity of a peak, the most salient features being crags of gritstone, such as Almes Cliff (Kinder Grit), Brimham Rocks (Third Grit), and the rocking-stones on Roggan Moor, so celebrated in the annals of shooting. The Millstone Grits of this district contain waters of remarkable purity, and the valley of the Washburn is now the storehouse for Leeds, just as Loch Katrine is for Glasgow.

On reaching the valley of the Wharfe at Bolton a different kind of country begins to appear, though Bolton may be regarded as partaking of the Millstone Grit scenery of Claro, and of the Carboniferous Limestone scenery of Craven, where the hills are usually tabular, but with here and there a peaked termination. The weathering of the Carboniferous Limestone has produced long scaurs or cliffs, such as those at Malham, Gordale, and Kilnsea. The climate being wet, and the soil generally calcareous, Craven is given over almost wholly to grass and forms some of the very best and most feeding pasturage in England. Skipton is the principal town, and has always been regarded as its capital.*

We obtain our knowledge of the geology of the country round Harrogate chiefly from Fox Strangway's "Memoir," whilst the work of Davis and Lees treats of the West Riding as a whole.

The Permian rocks in the eastern part of Claro, though mostly unfossiliferous, are not without interest. The Lower Marl has a very slight development, but five feet of red and grey marls belonging to this section are to be seen in St. Helen's Quarry, south-east of Knaresborough. These are the marls to which

* It used to be said that a squirrel could go from Knaresborough Castle to Skipton Castle without once touching the ground. Those were the days when Knaresborough Forest was covered with "*silva minuta*," most of which has long since disappeared.

allusion will presently be made in connection with the subject of rock-staining.

The most important member of the series is the Magnesian Limestone. But few fossils have been found in this district, and those chiefly from the lower beds, though traces of *Axinus* may be seen in beds which are highly dolomitised. At Knaresborough the yellow earthy variety is most frequent. It lends itself to the formation of caves, and, owing to its peculiar colour, imparts a character to the gorges through which nearly all the rivers of the West Riding have to pass on their way into the Vale of York. Most of these earthy varieties contain probably about twenty-five per cent. of carbonate of magnesia; they are quite useless as building-stones, but make excellent mortar. This porous, spongy sort of rock passes into yellow crystalline dolomite, frequently showing coloured bands, the more ferriferous varieties being studded with radiations of a metallic oxide, which is probably magnetite.* No purer form of dolomite than this would seem to occur in the Knaresborough district. But a few miles further south the crystalline dolomites of Huddleston Quarry are famous; there occurs also in Towton Field a form of Magnesian Limestone which is concretionary in small ovoids, almost resembling an oolite.

The Middle Marl succeeds the Magnesian Limestone, and in some cases must overlap it. This sub-division consists of red marls and soft red sandstone with much gypsum. Above it some small remains of the Upper Limestone are visible in a cutting to the west of Knaresborough.

The association of gypseous marls with beds of magnesian limestone is worthy of attention as having an important bearing on the origin of magnesian limestones generally, regarding which there are so many rival theories. Is the double carbonate a contemporaneous product, or the result of subsequent dolomitisation? Some are disposed to regard the formation of magnesian limestone as the result of precipitation in an inland sea, or, at any rate, of deposits due to streams charged with carbonate of lime and sulphate of magnesia, when, as Sterry Hunt has endeavoured to show, dolomite and gypsum would be the products. Prof. Green thinks that the palæontological facts noted in the Magnesian Limestone of Yorkshire favour this view, and he gives a history of

* These markings, on examination, are seen not to be dendritic; they may, nevertheless, contain some oxide of manganese.

the sequence of events, beginning with sandy deposits (the quicksands at the base of the Permian in South Yorkshire), which pass into sandy dolomites, and thence into pure dolomite. The fossils occur mostly in the lower beds, and as the waters became more highly charged with saline matters so life became scanty and dwarfed. He also looked to volcanic action as a source of supply for magnesian salts; but Mr. Lucas pointed out that the requisite materials might have been derived from the Yoredale Rocks and Millstone Grit of the neighbourhood, which were in all probability already above water. These questions have an additional interest as bearing on the probable position of the old shore-line of the Permian sea in these parts, and on the date of the Pennine upheaval.

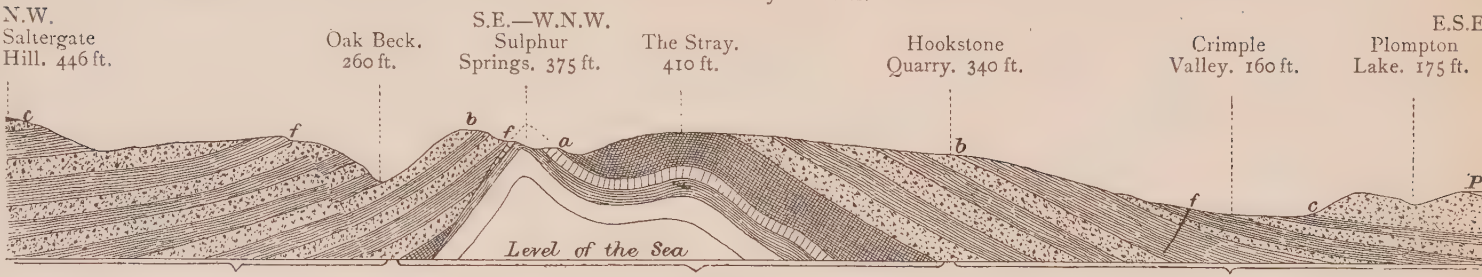
The Millstone Grit series is classified by Davis and Lees under the head of shore deposits with marine intercalations. The name serves to show the misleading character of a petrological title, as the group is full of shales, often with much ironstone, the smelting of which in former years had much to do with the disappearance of wood from Knaresborough Forest.

In the neighbourhood of Harrogate and Knaresborough the upper divisions of the Millstone Grit, including the "Rough Rock," are wanting, the highest beds now found belonging to the "Third grits." This circumstance is of course the result of pre-Permian denudation, which has not only removed the Coal measures, but a considerable portion of the Millstone Grit likewise. Consequently, in this district, the Permians repose unconformably upon certain quartzo-felspathic grits, which are often of a red or purple colour. These are largely developed throughout many parts of the drainage area of the River Nidd, appearing in moderate elevations at Plompton,* but rising to a height of nearly 1,000 feet above sea level in Brimham Rocks.

The coloration of these beds has been the subject of much controversy. The causes which have produced rock-staining in the lower beds at the junction of the Permian and Carboniferous in these parts may not be all of the same nature. Mr. Ward thought that the prevalence of a red colour in the underlying rock might be due to some action exerted by the Magnesian Limestone on the percolations; and this notion has attained a certain degree of acceptance, though it is difficult on chemical grounds to see

* For Plompton Rocks, see Ward, Quart. Journ. Geol Soc., vol. xxv. p. 291.

FIG. 193.—DIAGRAMMATIC SECTION THROUGH THE HARROGATE ANTICLINAL.



Millstone Grit series on the north side of the Anticlinal. | Anticlinal of Yoredale rocks. | Millstone Grit series on the south side of the Anticlinal.

Explanation of Signs.—a. Harrogate roadstone. On the north side of the anticlinal this is forced against the principal fault (*f*). *b.* The Uppermost Kinder Grit. Quarried on the south side of the anticlinal at Hookstone; on the north side of the anticlinal forms Birk Crag. *c.* Approximate position of the fossiliferous band (Cayton Gill Beds) in the Millstone Grit on either side of the anticlinal. *P.* Permian Beds (here Magnesian Limestone) resting unconformably on the Plompton Grits.

The YOREDALE ROCKS are here composed of—*Lower Grits*, *Lower Shale*, *Calciferous Encrinital Grit* (Harrogate roadstone, *a*) *Upper Shale.*

MILLSTONE GRIT.—The three lowest Grit beds with their accompanying Shales are called the *Fourth*, or *Kinder Grits.* A thick Shale intervenes. The upper series of Grits and Shales are referred to the *Third Grits.*

This section may be regarded as approximately correct as far as the surface is concerned. The folding of the Yoredale Rocks beneath the Stray is, to a certain extent, hypothetical. When the railway was made across the Stray the beds were observed to be so much disturbed that it was thought by some that the principal axis of elevation was at this point, rather than at the Sulphur Springs.

The Millstone Grit series consists very largely of Shale. It must not be supposed that the relative thickness of the Grits and Shales is accurately delineated in the diagram. Even the Plompton Grits, which form the highest section of the Third Grits in this district, are by no means free from associated Shales.

exactly what the nature of such action can be. Moreover it is quite an open question whether there really is any increase of red colour in the grits which lie beneath the Magnesian Limestone; indeed, that there is any such increase is denied by Mr. Lucas, who, as before mentioned, was inclined to attribute some of the red colouring to a lower marl now removed. In many parts of the Nidd valley the stratum of grit in actual junction with the Magnesian Limestone is often less highly coloured than the bed below. There can be very little doubt that much of the red colour of the Plompton Grits is due to the quantity of red felspar which they contain, so that possibly the principal causes were pre-existent within the rock itself.

The fossiliferous horizon known as the Cayton Gill beds (*c* of the diagram, Fig. 193) is seen on both sides of the Harrogate anticlinal. *Productus semireticulatus* is the most abundant fossil; *Streptorhynchus crenistria* is fairly plentiful, as also a very pretty *Fenestella;* the joints of Encrinites are very abundant.

Kinderscout Grits.—The base of the Millstone Grit consists of three thick grit beds associated with still thicker shales. Some of these grits have been extensively used for building-stone at Harrogate, but they are very porous. Though usually pretty free from strong colours, some of these beds are very purple in places, though exposure soon removes the tint. The outliers of the Millstone Grit series in Craven mostly belong to this section.

Yoredale Rocks.—This is a group established by Phillips for a variable series of beds between the Carboniferous or Scar Limestone of Craven and the Millstone Grit. It is well developed in Craven and throughout the west, consisting of shales, limestones, and peculiar grits, often calciferous. In the bed of the Hodder, Yoredale Shales, with their limestones and layers of ironstone, give rise to springs containing sulphuretted hydrogen. In Bowland Forest these shales are dark and full of molluscan and fish remains. Near Skipton the Yoredale Rocks consist of calcareous shales and limestones with many fossils, the beds sometimes being of a ferruginous and bituminous character; sulphur springs occur here in a position somewhat analogous to those at Harrogate. The attitude of the Yoredale Rocks at the latter place may be gathered from the diagram, Fig. 193. Very little is known about the shales of this group, but the Harrogate roadstone (*a* of the diagram) is a remarkable rock; below this are other shales and another peculiar grit.

The Yoredale Grits at Harrogate are so peculiar that, being in

some way connected also with the phenomena of the sulphur springs, a brief description may be useful before proceeding to consider the subject of the waters themselves. A large hand specimen from the Beckwithshaw quarry shows three different phases. Firstly, a fine-grained quartzo-felspathic grit without lime; secondly, a calciferous encrinite grit, where the lime has mostly been removed, but where the structure of the crinoidal stem is better brought out in consequence; thirdly, a more calcareous portion. A hand specimen from the bottom of the sulphur well on Harlow Carr is a very fine-grained quartzo-felspathic grit with much white mica, and coaly matter in bands and blotches. In the Low Harrogate quarry (Cold Bath Road) the crinoidal character is very prevalent, and where the soluble matter has been removed it becomes a spongy, silicious, encrinite grit. The decomposition of this rock produces a good soil, but we may well believe that the surface beds have already parted with some of their constituents, and the iron-stained nature of the joint-faces points in the same direction; it is in the stuff formed in these cracks that the little double-pyramid quartz crystals, known as Harrogate diamonds, have been deposited.

The Harrogate waters,* both sulphur and iron, occur in connection with a triangular patch of Yoredale Rocks, of which a cross-section is seen in Fig. 193. This patch is bounded towards the N.W. by the main fault, and extends for about three miles S.W. of Harrogate. There are about eighty springs in all. The strongest waters rise in the little valley of Low Harrogate, between the Bog Field, 375 feet, to the Montpelier Spa, 335 feet. This is the nucleus of the sulphur waters; the strong iron waters are near, but usually occupy an outer area. It is evident that an iron water and a sulphur water are incompatible, yet they wait closely on each other and must in some way be connected. One of the great puzzles is to understand how they are kept apart in the ducts which convey them to the surface. The very high angle of the beds and the peculiar jointing of the encrinite grit have probably something to do with it.

The composition of the Harrogate waters has often been studied from a therapeutical point of view, but it has also its geological aspect, and recent observations have brought out some features of considerable importance in this direction. Henceforth there will be less difficulty in understanding the vein deposits of the

* For further details consult "The Harrogate Waters," by George Oliver, M.D.—H. K. Lewis, London.

Carboniferous series, as here we have an opportunity of testing the vital fluids of the rocks, as it were, in the act of circulation. An inspection of the accompanying table may serve to illustrate this.

The five waters whose analyses are there given are representative of the chief varieties. Technically the *sulphur waters* are divided into strong saline, mild saline, and pure, the latter term being merely relative. It may also be noted that No. 3, selected as a type of the "pure sulphur," is situated at some distance from the triangular patch of Yoredale Rocks previously mentioned, and very near the junction of the Millstone Grit Shales with the Middle Permian Marls. At the same time it is not improbable that this spring may represent an overflow from a spring at Bilton, which is more in the direction of a slight prolongation of the anticlinal axis. In consequence of the absence from this water of the chlorides of the alkaline earths there is a fair amount of alkaline carbonate, and the same is the case with the spring at Harlow Carr on the other side of Low Harrogate. In fact the further away from Low Harrogate the less amount of chloride occurs in the sulphur springs.

The old sulphur well yields a pretty uniform supply, amounting to about twelve gallons per hour, though in the very dry year, 1868, there was some mention made of a threatened deficiency. The temperature is evidently pretty nearly that of the air, so that no appreciable amount of extraneous heat can be detected. Indeed it may be said that all the waters of Harrogate are "cold," and, with one exception (the alum well) they all have a markedly alkaline reaction. Calculating roughly, the old sulphur well would yield seven tons of chlorides per annum, including 100 lbs. of barium chloride,* and 37 lbs. of magnesian bromide, with some iodide. It also would produce 240 lbs. of sodium sulphydrate (NaHS).

The origin or source of these abundant impregnations has naturally been a matter of considerable difficulty. The most probable explanation is that the springs, though not superficial, are far from being deep-seated, and that the water supply comes mostly from the Harlow Hill district, which attains 600 feet elevation, and attracts a rainfall that cannot well average less than thirty-five inches annually. That the supply is not superficial may

* Barium chloride was not noticed by Hoffman in 1854, and that chemist only found traces of bromides and iodides. Improvements in methods of analysis may account for the difference.

be inferred from the fact that the drainage of the Bog Field had no effect on the delivery of the waters, and thus the notion held by Phillips as to the origin of the sulphur waters would seem to be untenable. The large quantity of chlorides looks very much as if a portion of the water of the sea or of an estuary * had been evaporated and the salts incorporated with the Yoredale Rocks during their formation. There is abundant evidence, both in this neighbourhood and elsewhere, of the quantity of organic matter, chiefly of vegetable origin, locked up in the Yoredale Rocks. Hence it is not unreasonable to believe that the putrefactive distillation of such organic matter, acting very slowly and through long periods of time, more or less effects the complete deoxidization of the sulphates, and that to this we owe the quantity of sulphide present in the Harrogate waters. The considerable quantities of carburetted hydrogen and of nitrogen found by Hoffman all favour this view, which is much strengthened by the almost complete absence of oxygen, showing that the nitrogen present is due to organic decomposition. At the same time the slightness of traces of phosphoric acid would show that this mainly arises from vegetable matter.†

EXCURSION.

Monday.—The members arrived at Harrogate and assembled at the Old Sulphur Well. Mr. Hudleston offered a few remarks on the chemical composition of the water and of several of the sulphur waters of Harrogate. He was enabled to illustrate his observations by means of a number of specimen tubes containing

* Comparing the total solids of the Mediterranean with those of the Baltic, the following differences may be noted:—

	Mediterranean.	Baltic.
Solids in 100 . .	3·77	1·77
Haloids, per cent. .	89·5	94·5
Sulphates . . .	10·2	5·2
Carbonates . .	0·5	0·3
	100	100

See "Bischof.," vol. i. pp. 105, 107.

† In the Report in the Proceedings analyses of the water at

No. 1. Old Sulphur Well,
2. "Magnesia" Well,
3. Starbeck Spa Water (pure sulphur),
4. "Kissengen" Water (strong saline chalybeate),
5. St. John's Well (pure chalybeate)

are given.

the saline contents of one gallon of each of the various waters to be found in the town. These very interesting tubes had been prepared from evaporations conducted by Mr. Davis, chemist, of Harrogate. They are the property of the Harrogate Improvement Commissioners, who kindly lent them for the occasion. Whilst the company were thus engaged, Dr. Oliver, the author of a work on "The Harrogate Waters," appeared at the wells and supplemented the President's observations. Dr. Oliver dwelt more especially upon the geological conditions under which the water finds its way to the surface in connection with the very remarkable anticlinal which is known to exist at Low Harrogate.

The singular stratigraphy of Harrogate arrested the attention of geologists a long time ago. William Smith, the father of English geology, was the first to appreciate the peculiarity, but although he recognised that there was an anticlinal or upthrust of lower rocks, extending from Harlow Hill to Low Harrogate, he appears to have thought that within that anticlinal there was a synclinal basin, towards which the springs gravitated. Later on, his nephew, the late Professor Phillips, who for forty years had given great consideration to the peculiarities of the geology of Harrogate, drew the attention of the Geological Society of London to the very remarkable features of the district, the difficulties in regard to which had been to some extent cleared up by the making of the new railway across the Stray. The subject of the anticlinal was treated generally in a diagram in the paper by Phillips, and the relation of the Millstone Grit beds on the north and south of the Yoredale rocks beneath was made very clear. At the same time Phillips seems to have had a notion that there was a sort of synclinal towards the apex of the anticlinal, and his section at this part of the diagram is somewhat obscure and difficult to comprehend.

When the party left the Old Sulphur Wells they proceeded to verify the stratigraphical facts in connection with the anticlinal, and for this purpose walked to the well-known road-stone quarry in the Cold Bath Road. This stone is one of the hard beds of the Yoredale Rocks, and may be described as a calciferous grit very largely charged with the remains of crinoids. In the Cold Bath Road quarry these rocks are to be seen dipping at a considerable angle in a south-easterly direction. In the bed of the stream, just at the back of the sulphur well, the same rock is observed to dip in a direction somewhat to the north of east, and a little further up the hill, underneath Cornwall House, this same

bed dips at a very high angle indeed, nearly due north. These facts are taken to indicate that there exists an anticlinal dome, which is here seen to be dying out to the eastward, and the north side of the anticlinal is very much steeper than the south—in fact, the anticlinal itself is fractured a little on the north-west side of what may be presumed to be its principal axis by a great fault which causes the road-stone to be brought into juxtaposition with the lower beds of the Millstone Grit. There are geologists at Harrogate who consider that the axis of this swelling or anticlinal is to be found beneath the Stray rather than at the sulphur springs, and this view receives some substantiation from the appearances which were noted when the railway was made across the Stray. The probable explanation is that the Harrogate road-stone and its accompanying shales are bent into more than one series of curves, and that one of these curves very nearly reaches the surface in the railway cutting. A northerly dip of the beds near Low Harrogate Church is further evidence of the probability of this view.

The party having satisfied themselves as to the reality of the anticlinal axis were conducted to the Bog Springs, where there are something like thirty-four different sources of sulphur and iron waters. Dr. Oliver here indicated the peculiarities of the position and the nature of the several waters, and deduced from his observations the fact that, as a rule, the sulphur springs occupy an inner position, and that the iron springs are without, on either side of the main axis of upheaval. The nature of the several wells was pointed out, and attention was especially drawn to the very abnormal water known as the "Alum Well." It may be mentioned that one of the characteristics of the sulphur waters at Harrogate is the absence, more or less complete, of sulphates. This peculiarity enables many of the Harrogate waters to act as carriers of salts of barium and strontium, which would otherwise be insoluble. In the "Alum Well," however, a large quantity of sulphates exists. The probability is that this is due to the shallow origin of the spring, whose waters become oxidised, and this may account also for the acid reaction so exceptional to the waters of this neighbourhood.

Having spent some time at the springs, the company walked to Birk Crag, where they had an opportunity of looking from that very picturesque ridge of Millstone Grit over the wild and dreary scenery of Haverah Park, which consists entirely of the grits and shales of the Millstone Grit group. These rocks are noted for the

purity of their waters. Oak Beck, which flows through Haverah Park, has been utilised for the purpose of supplying the town of Harrogate with pure water, just as the Washburn river has been adapted for supplying Leeds. The remainder of the evening was spent by the party in walking round by Harlow Carr and the back of Harlow Hill to Harrogate.

Tuesday.—The party left Harrogate for Knaresborough, and after a brief inspection of the old castle at the latter place descended to the foot of the cliff on which what is left of the ancient pile stands. Here the unconformable junction of the Magnesian Limestone with the Millstone Grit was pointed out by the Director and verified by the members. From this point the party crossed the river for the purpose of visiting the Dropping Well. The Director took occasion to explain the nature of the waters which flow over the rock. The stream supplying these waters springs out of the adjacent cliff, and represents the drainage of a hollow originating in the high ground towards Belmont. This ground is chiefly made up of the Middle Permian Marls, and it is to the salts in these marls that we must trace the impregnation of the Dropping Well waters. The following is an old analysis of the water:—

	Grains to the gallon.
Carbonate of soda	6
Carbonate of lime	23
Sulphate of lime	132
Sulphate of magnesia	11
Total . .	172

The deposits upon the sponges and other substances which are placed at the well consist almost wholly of carbonate of lime, the amount of sulphate of lime deposited being very small indeed, notwithstanding the very large quantity of sulphate of lime found in the water. Mr. Simpson, the lessee of the Long Walk and the Mother Shipton Inn, recently possessed himself of some magnificent specimens of sponges, which show the action of the deposit remarkably well from their porous nature. Some time was spent by the party in examining the various caves in the valley of the Nidd, and in listening to stories about St. Robert and Eugene Aram, after which they crossed the river at Grimbald Bridge, and finally took leave of the Magnesian Limestone where the romantic Grimbald Crag is terminated by a small fault on its western side.

Plompton Rocks—a mile and a half distant—were very soon reached. These rocks are interesting to geologists from having been regarded in former days as constituting a portion of the Permian series—equivalent to the German "Rothliegende." The researches of the Government surveyors in recent years have shown that these rocks are really nothing more than the highest beds of the Millstone Grit series, as developed in this district, and that they are unconformably overlaid, just as at Knaresborough, by the Permian rocks. The extraordinary action of the weather upon these curious grits afforded matter for endless speculation. In this respect the Plompton rocks, which belong to the same bed of grit which forms the Brimham rocks at a much greater elevation, are possibly more singular and grotesque than even the Brimham rocks themselves.

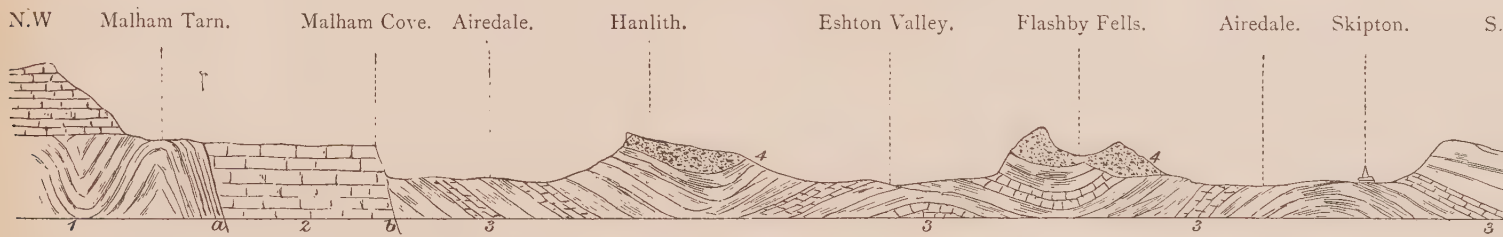
In the afternoon the members drove to inspect the new quarry of Harrogate road-stone at Beckwithshaw, where the effects of contortion are very finely displayed. A small spring of sulphur water has recently been discovered near here by Dr. Oliver.

Wednesday.—This was an important day for the excursionists as they had to transfer themselves in conveyances from the base of operations at Harrogate to Skipton, *viâ* Knaresborough Forest and Bolton. The early part of the journey was sufficiently dreary, the scenery of this part of Knaresborough Forest being somewhat tame and uninteresting. A number of fossils were discovered on the stone-heaps near the "Little Wonder" Inn, coming from the well-known quarries in the Millstone Grit series near Hampsthwaite, on the horizon known as the "Cayton Gill beds" (see Fig. 194). The excessive rarity of fossils in the Millstone Grit makes their occurrence in this bed of considerable interest. The species appear to differ but slightly from such as are known to occur in the Carboniferous Limestone. Having safely passed the "dangerous corner" the Director (Mr. J. W. Davis) and his followers descended into the valley of the Washburn, where the extraordinary size of the artificial lakes provided for the Leeds water-supply struck every one with astonishment. The Pass of Kexgill, the next object of interest on the route, shows traces of the anticlinal axis in the way in which the grit rocks dip on either side. Having reached the summit of this pass the party drove rapidly down the descent to Bolton Bridge, and at about half-past twelve arrived at the "Devonshire Arms." About four hours were devoted to Bolton Abbey and the Strid, where many of those from the south saw for the first time one of the most

beautiful and interesting spots in Yorkshire. It may be stated that the Strid is cut through what is known as the Kinderscout Grit, or lowest grit of the Millstone Grit series. Opposite Bolton Abbey there is a very fine section in the Yoredale Shales, showing both faults and contortions. This is on the north side of the anticlinal. The stratigraphical phenomena between Bolton and Skipton are of the most marvellous kind. (See Fig. 194, S.E. side, for the general structure of the Skipton Anticlinal.) The long system of disturbance extending from the neighbourhood of Clitheroe to Harrogate here assumes a most striking phase, and the quarries in consequence exhibit some extraordinary sections. The first quarries visited are known as the Hambleton Rock Quarries, where the Skipton Rock, supposed to be Mountain Limestone, has been forced into a vertical position and is variously contorted. Continuing the drive towards Skipton, the party made a diversion in the direction of Draughton Quarry, an excavation in the Yoredale Rocks, where the most remarkable phenomena of rock-curvature may be seen to great advantage. Skipton was not reached until a late hour in the evening.

Thursday.—This morning the party travelled from Skipton to Bell Busk, and walked from that station to the village of Malham, a distance of nearly five miles. The hillocky character of the intervening country is chiefly due to the prevalence of glacial deposits. Malham Cove is situated not far from the south branch of the Craven fault. (See Fig. 194, N.W. side). The Director having arrived at the foot of that remarkable cliff, just where the River Aire springs from the base of the precipice, drew attention to the geological characteristics of the scene, more especially in connection with the underground course of the water, which disappears a little to the south of Malham Tarn. The party retraced their steps in the direction of the village of Malham, and thence walked towards Gordale Scar, some of the gentlemen visiting Janet's Cave on the way. The gorge at Gordale is an excavation in what is known as the Scar Limestone, which is the lowest member of the Carboniferous series in this district. The stream which flows through this extraordinary cañon, by its numerous waterfalls, adds largely to the interest of the scene. There can be very little doubt that this excavation is almost entirely the result of water action, aided to a certain extent by rock-jointing in the first instance. The scramble up the gorge was a somewhat difficult undertaking, and the whole of the party finally stood on the limestone pavement of the moors above.

FIG. 194.—DIAGRAMMATIC SECTION FROM MALHAM TO SKIPTON. Distance 12 miles.



Explanation of Signs.—1. SILURIAN GRITS. 2. MOUNTAIN LIMESTONE. 3. YOREDALE SERIES. 4. MILLSTONE GRIT. *a*. North branch of Craven Fault; *b*. South branch.

This section is designed to give an approximate idea of the position and contorted character of the rocks in the vicinity of the Craven fault, and for many miles southward. The surface of the valleys is for the most part thickly covered with glacial clays, sand, and boulders; but where exposures of the rock are met with they always exhibit a more or less contorted section. At Malham Tarn the Mountain Limestone extends in more or less horizontal beds on the upturned edges of the Silurian Rocks. The grit rocks which occupy the higher ground at Hanlith and Flashby Fells are in the form of synclinals, whilst the summits of the anticlinals occupy the lower parts of the valleys. At Skipton a limestone is quarried, which is supposed to be equivalent to the Mountain Limestone at Malham, but this is by no means certain.

From thence a rough walk led them to within a short distance of Malham Tarn, which is said to be situated on Silurian Rocks and Boulder Clay.

At the place where the water sinks, to reappear, as already stated, at the foot of Malham Cove, Mr. Davis read a very interesting communication from Mr. Walter Morrison with reference to the underground course of the water, which disappears at this point. The Director expressed his opinion that the water at once falls into the north branch of the Craven fault, which crosses the moors about this spot. The kindness of Mr. Morrison in offering the party the use of boats and other facilities was duly acknowledged. Here the party divided. Some of them returned at once towards Malham, whilst the other portion took the road across the moors for the Victoria Cave and Settle. Both sections arrived at the Victoria Cave about the same time. Certain observations relative to the position of the great north fault were made by some of those present. This party finally descended into Settle by a very precipitous route. After a hurried visit to the museum at Giggleswick, where many of the objects found in the Victoria Cave are arranged, including the largest specimen of the grizzly bear which was ever found fossilised, the excursionists got to Settle station just in time to catch the train for Skipton.

Friday.—On Friday morning, in a heavy shower, the party proceeded from Skipton to Clapham. On their arrival at the latter place the clouds broke and it was comparatively fine for a few hours. This enabled Mr. Davis to take his followers through the grounds belonging to Mr. Farrer, where the effects of one of the great faults are very well shown in the gorge of the stream. A section of the party then visited the celebrated Clapham Caves, whilst a smaller number proceeded up Trout Gill to Gaping Ghyll Hole. It is very well known that the waters which are collected on the southern flanks of Ingleborough, and which flow as an ordinary beck up to this point, suddenly disappear in the yawning limestone, just as one might imagine a river turned into a pit-shaft. The waters are doubtless those which reappear close to the Clapham Cave. At some time or other the course of this stream was on the surface, and the lines of the old valley are still to be seen, though the stream no longer excavates that portion of the valley between Gaping Ghyll Hole and the place of its final emergence into daylight at the Clapham Caves. It may be as well here to draw attention to the readiness with which water sinks in these limestone districts—a circumstance due partly to the

jointing of the rocks themselves and partly to their solubility in carbonated waters.

Both branches of the party ultimately returned to Clapham, where they reassembled at the New Inn.

The rain was now coming down in torrents, and very few of the members showed any anxiety to carry out the programme to its final completion. Only ten were found to enter upon the undertaking, including the President and the Director. These walked, in a pouring rain, first of all to Norber—a distance of over a mile—where they saw the magnificent display of ice-borne boulders of Silurian rocks resting on Mountain Limestone. By the hamlet of Wharfe the small party walked round Moughten Fells to Foredale. At Combe Quarries they had to be satisfied with a glimpse at the section where the Mountain Limestone lies unconformably on the upturned and folded edges of the Silurian slates and grits, and thence walked to Horton-in-Ribblesdale, in time to catch the train to Skipton.

SATURDAY.—The contemplated excursion to Raygill Quarries was abandoned, in consequence of the threatening nature of the weather. It may be mentioned that at Raygill Quarries there is a fissure recently excavated by the Yorkshire Geological and Polytechnic Society. The bones of elephant, hippopotamus, rhinoceros, bear, hyena, lion, bison, and other animals have been found in the quarries, and are now in the museum of the Leeds Philosophical Society.

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CUMBERLAND.

EXCURSION TO THE LAKE DISTRICT.

MONDAY, JULY 18TH, TO SATURDAY, JULY 23RD, 1881.

Directors—W. H. HUDLESTON, F.R.S., Prof. J. MORRIS, F.G.S., C. E. DE RANCE, F.G.S., and W. KINSEY DOVER.

(*Report by* THE DIRECTORS.)

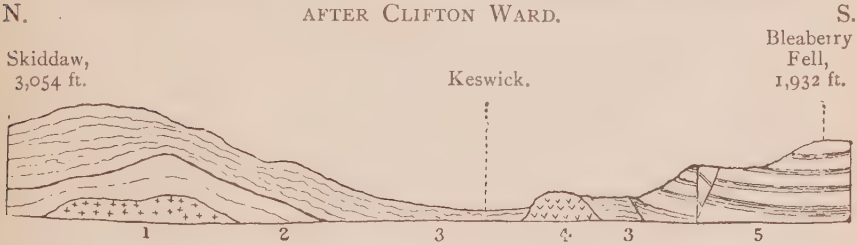
(*Proc. Vol.* vii. *p.* 236.)

THE greater part of the excursionists arrived at Keswick on Monday evening, and were located at the Keswick Hotel. After dinner they proceeded to Friar's Crag and made a cursory inspection of the geological features there, and the beautiful prospect of the lake which that point affords. On Tuesday morning the party met at the museum of Local Natural History to inspect the rock specimens collected mainly by the Rev. J. Clifton Ward. In addition to these, Mr. Christopherson lent a magnificent specimen of pure Borrowdale plumbago. Mr. Hudleston, in a brief address, said there were few country towns possessing such an excellent museum of local collections, and the circumstance was due to the Keswick Literary and Scientific Society. In this museum almost every object was specially calculated to illustrate the topography, the natural history, or geology of the district; that was what all museums should aim at. Among the names to be specially mentioned there were two—the first, Mr. Flintoft, the maker of the relief model of the district, which for nearly half a century had been studied by almost every tourist. The model at Mr. Mayson's, from the Ordnance Survey, might be more accurate, yet any one wishing to get a general idea of the district could not get a better one than from Flintoft's model. There was one other name, but his removal having been so recent, one could not refer without feelings of regret to James Clifton Ward. He was the great illustrator of the geology of this region. The map, 101 S.E., was one of his most remarkable works; the district had

been a puzzle for years, but Clifton Ward had worked it out, and now the geology of few parts of the country was better known. After alluding to the work of Professor Sedgwick, and of Harkness and Nicholson (who, with the aid of Joseph Graham, did for the Skiddaw Slates what Clifton Ward did for the Volcanic series), the speaker referred to the work of the Crosthwaite family, and their excellent museum, which had existed for nearly a century, and part of which was to be found in the British Museum. He next briefly touched upon the labours of Jonathan Otley. As present-day workers among fossiliferous remains, the speaker mentioned Mr. Christopherson and Mr. Kinsey Dover.

Mr. Hudleston then gave a short sketch of the geological features of the neighbourhood. Immediately afterwards the party left the Town Hall and proceeded to inspect the quarry at Castlehead. This beautifully wooded hill is entirely composed of an eruptive rock which burst through the Skiddaw Slates, most probably in early Silurian times, and may be regarded, according to the late Clifton Ward, as the plug formed in the lower portion of a volcanic vent which contributed to the enormous outflow of

FIG. 195.—DIAGRAMMATIC SECTION THROUGH KESWICK, MODIFIED AFTER CLIFTON WARD.



1. Skiddaw Granite.
2. Spotted and Chiastolite Schists.
3. Skiddaw Slates.
4. Castlehead eruptive trap (doleritic).
5. Volcanic series.

lava and ashes occupying the base of the great group of rocks, formerly known as the "Green Slates and Porphyries," but more recently as the "Volcanic series of Borrowdale." The composition of the well-known bedded lavas of Falcon Crag is sufficiently near that of the eruptive rock of Castlehead to render the supposition a very probable one. To inspect this remarkable series of lavas and ashes the party accomplished the feat of scrambling up Catgill. The great lava bed of Falcon Crag, 150 feet thick, consisting of a dull blue whin—not at all a handsome rock in hand

specimens—is seen to rest upon a bed of volcanic ashes in the middle part of Catgill; beyond this the stream turns at right angles to its previous course, occupying a line of fault which runs for some distance at the back of Walla Crag. A sharp climb brought the party to the little waterfall precipitating itself into Catgill from the east, and here they noted the very clearly indicated junction of a lava, having a vesicular base, with some green ash partially cleaved and distinctly bedded. The clinometer showed a dip of 9° south-east. Most of the beds on this side dip in the direction of Bleaberry Fell, which occupies a synclinal, as is so often the case with high grounds.

The next move was to the summit of Falcon Crag, where Mr. Jenkinson pointed out the topography. The view is very extensive and enables the spectator to contrast the scenery of the two sides of Derwentwater, the smooth and rounded outlines on the west being due to the forms assumed by the Skiddaw Slates under the hands of that grand old sculptor, Time, with rain and frost for his most effective chisels. The Volcanic series on the south and east refuse to take so smooth a polish. A good instance of this may be seen on the summit of Falcon Crag itself, where the pressure of ice during the glacial period has most distinctly rounded off *(moutonnée)* the south side, but the rugged nature of the rock (a rather coarse ash on the summit) is beginning to show itself once more under the influence of the ordinary agencies of denudation. The ice during the glacial period filled up the valleys to about 1,500 feet on the Bleaberry Fell range, each valley system being for the most part independent, though in one case the watershed between Bleaberry Fell and Seat may have been overridden so as to give passage to certain boulders of the Armboth elvanite. Regarded as a whole the Lake District manufactured its own boulders, and as it kept the Scotch and all other rocks from its slopes the glacial phenomena of the region afford no colour to the notion of an universal ice-cap.

A heavy climb gained Falcon Crag and the summit level of the walk, a little to the south of Bleaberry Fell, whence the descent to the brow of Shoulthwaite Gill was easy. Here the chief difficulties of the day commenced, and as the leader was determined to find the lava which occupies the base of Iron Crag at the south end, something like a disruption of the party occurred. However, the lava was found, the steep descent was safely accomplished by all, and the mural aspect of Iron Crag duly appreciated in safety from the bottom. Interesting specimens

of rocks were secured in the passage down Shoulthwaite Gill, including some remarkably fine bedded ash and the garnet rock of Sippling Crag. On reaching the Ambleside road a large number turned down the Naddle valley, where they ransacked the walls for specimens of the beautiful red porphyry of Armboth, which is plentifully distributed throughout this region, and disdaining the high road, tried a short cut across the bogs below Goose Well, and finally crowned a well-spent day by a visit to the Druid's Circle on their way to Keswick.

On Wednesday morning train was taken to Threlkeld station, whence the party visited the quarry in the St. John's quartz-felsite. Mr. Bullen kindly afforded every facility for exploring this very interesting section, which shows a faulted junction with the Skiddaw Slates. The stone, believed by Ward to be the result of the metamorphism of a mixture of the Skiddaw Slate and Volcanic series, is being largely quarried for paving, and the manager speaks in sanguine terms of the future development of the works. It is thought that as the quarry advances further into the hill the rock will assume a more granitoid aspect.

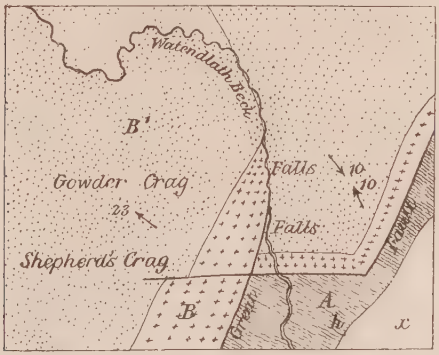
The next move was for the western shoulder of Saddleback, past High Row, and up Glenderaterra. The Skiddaw Slates of this region dip for the most part at moderate angles towards the north-west. They are black and glossy, but with very few traces of fossils. When nearly through Glenderaterra the metamorphic belt, containing crystals of chiastolite, was reached. That this belt really is metamorphosed Skiddaw Slate, and not some under lying formation, has beeen proved indisputably of late by the discovery in the Chiastolite Slate on Skiddaw Top of a well-preserved trilobite, now in the Keswick Museum, supplemented by the discovery of a graptolite in a similar matrix, the latter specimen being in Mr. Kinsey Dover's collection. No junction of this rock with the "Spotted Schists" was noticed, but the presence of these latter soon became manifest on the hill-side. Leaving the track the party started up Roughten Gill to the waterfall, where "Spotted Schists" are observed *in situ* with a sort of foliation dip of 70° to the south-east. This was the farthest point from home, and the return route was past the hill where the "Spotted Schists" have yielded so many specimens of the rock harmonicon, and thence into Sinen Gill, where the junction of the granite with the micaceous variety of the "Spotted Schists" occurs. It is the action of this granite, doubtless in connection with the much larger mass in the Caldew valley, which has produced the meta-

morphism of the slaty beds within a certain distance of its influence. This, at least, is the generally accepted view, and the discovery mentioned above strengthens the metamorphic theory. A call was made at Myrtle Grove, where, at the invitation of Mr. Dover, the members of the Association examined his fine collection of fossils from the Skiddaw Slates, the result of some years of research, and consisting chiefly of graptolites. At the request of the President, Professor Morris offered a few remarks on their nature. He pointed out that many different opinions had been advanced as to the systematic position of the graptolites, but the most favoured view considered them to be allied to the living sertularian zoophytes or "Sea Firs." Simply expressed, the typical form consisted of a row of horny cups united at their bases by a common tube into which they opened, and generally supported by a fibrous rod which projected from one or both ends of the polypary, in which they differed from their modern allies. The portions preserved constituted the skeletons only of the composite colonies or polypary of the ancient graptolites, but there could be little doubt that they were composed of flexible horny material, similar to the outer chitinous investment of the colonies of the modern sertularians. The more complex forms were produced by the combination in different ways of the above simple factors, hence these combinations were divided into numerous genera of the family Graptolitidæ. Some had a simple row of cells on one side only, as *Graptolites*, some had double rows, as *Diplograptus*, others presented a combination of the above two forms, as *Dicranograptus*, and a fourth type consisted of four series of cells, as *Phyllograptus*. Some genera were peculiar to the Skiddaw Slates, as *Tetragraptus*, *Phyllograptus*, and three others, but in the Quebec rocks of Canada, which were considered to be of the same geological age (Lower Silurian), about eight genera occurred which were common to both series. The specimens obtained by Mr. Dover were finer and larger than the Canadian forms, and from their state of preservation would perhaps assist in clearing up some further points in their structure and affinities.

Thursday saw the party at Lodore, where the Skiddaw Slates form a triangular wedge of low ground faulted against the mural rocks of the volcanic series, which are themselves cleft by a subordinate fault forming part of that remarkable chasm. Thence into Troutdale. A tongue of Skiddaw Slates runs up this mountain glen for some distance, forming the floor of the valley. A

low pass leads over into Borrowdale, and here the party, after inspecting the cleaved rough ash of these well-known slate quarries, just glanced at that enormous mass of fallen crag known as the Bowder Stone, and then hurried on through Rosthwaite and Seatoller towards Honister Pass. There is considerable analogy between the geological structure of this valley and that of Derwentwater; both are excavated in the Skiddaw Slates at their junction with harder rocks. In this case the Buttermere "Syenite" supplies the place of the Volcanic series. It is a handsome red rock, and will probably be worked some day. Scale Force occupies a cleft in the "Syenite" close to a faulted lode charged with red oxide of iron. The chasm, cut by water, probably owes its direction to the fault. The adjacent Skiddaw Slates are hardened, but no crystalline action has been set up. A portion of these slates has been carried to the top of Red Pike. Later in the day Mr. Blake discovered a junction between the Slates and "Syenite," a little east of Scale Force. There are no signs of gradual change, the contrast is complete, and the "Syenite" has all the appearance of an intrusive rock.

FIG. 196.—FALLS OF LODORE.



Six inches to one mile.

A. Skiddaw Slates.
B. Lodore Trap } Volcanic
*B*¹. Bedded Ash } series.
x. Alluvium bordering the lake.
h. Hotel.

On Friday the party left Keswick in somewhat unfavourable weather, but matters improved before the carriages reached Grasmere, where the party were met by Mr. C. E. De Rance, who carried out the Geological Survey of the Ambleside district between 1872-4. He pointed out the watershed that had just been passed at Dunmail Raise, between Wythburn and Grasmere, as part of the important central watershed crossing England from east to west, which is crossed by passes at various elevations, ranging from little above the sea-level between St. Bees and Whitehaven, to 1,380 feet at Kirkstone Pass, that on Dunmail Raise being only 775 feet; through the latter will be carried the aqueduct of the Manchester Corporation Waterworks, conveying the waters of Thirlmere Lake to South Lancashire. Grasmere Lake was stated to be a rock basin, eighty feet in depth, probably scooped out by glacier action, evidence of which action may be seen on the slopes of the valley on either side, to 1,200 feet above the level of the sea.

A halt was called to examine similar phenomena at the bottom of Rydal Water, where a glaciated *roche moutonnée* rises to a height of twenty feet above the level of the water, and has been cut through by the Rothay in a narrow gorge, giving passage to the overflow of the lake. South of this spot the river, being deflected by a rocky barrier opposite Rydal Mount, suddenly changes its direction, and flows past the *roche moutonnée* of Ambleside Church, long ago described by Lyell, following the line of a fault which ranges down the valley.

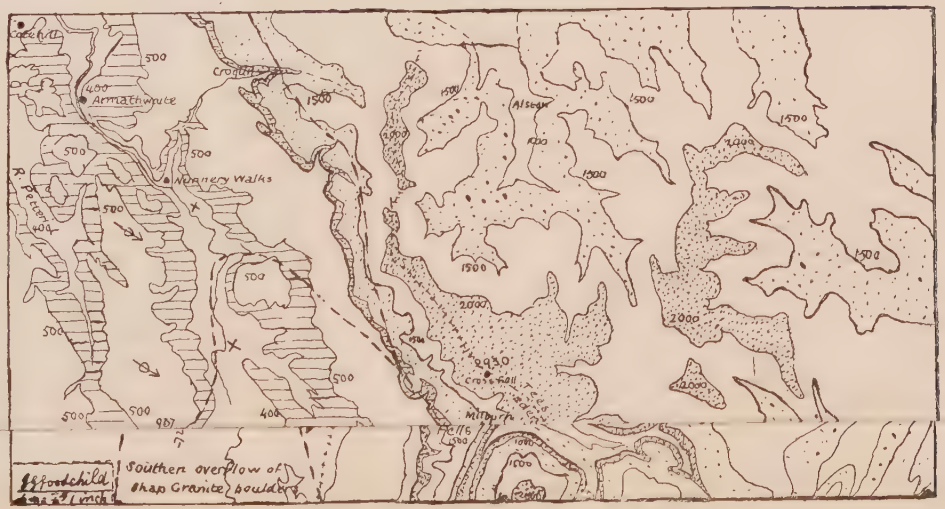
After lunch at Ambleside the party started by the footpath to Skelgill and Troutbeck, crossing the south-west slope of Wansfell, and passing over the higher beds of the Volcanic series, which here contain a large amount of altered material resembling white china, which has the appearance of having eaten into the rock in an irregular manner. This substance has a generally baked appearance, and is occasionally cleaved in small, less altered patches, in which condition it has been called "white-ash," as a convenient name, but not as implying any theory of origin. It is much traversed by small mineral veins and the whole rock is occasionally charged with a dust of sulphide of iron, and more rarely of sulphide of lead.

A halt was called on reaching the first eminence overlooking the Ambleside steamer landing-pier. The northern sky-line is made entirely of rocks of the Volcanic series, which form the central watershed before referred to; the whole of the country visible

GEOLOGICAL MAP OF CUMBERLAND AND WESTMORELAND.

CONTOURED MAP OF UPPER EDENSIDE, SHOWING WATERSHEDS AND DISTRIBUTION OF BOULDERS.

[*To face p.* 529.]



consequently drains into Coniston or Windermere Lakes, and eventually into Morecambe Bay. The strike of the Volcanic series is about east and west magnetic, and corresponds with that of the cleavage; but as may be seen between Ambleside and Keswick the anticlinal basis of the bedding corresponds to synclinals in the cleavage.

Mr. C. E. De Rance stated that on sounding Lake Windermere he had found it to be 39½ fathoms deep opposite Wray Castle, close to the western shore, and as the surface of the lake is only 134 feet above the sea, the bottom of the water is 100 feet below mid-tide level; and it was pointed out that the total depth of Windermere is somewhat greater than that of the English Channel between Folkestone and Boulogne. Moreover, when the River Leven has cut a deeper groove at the foot of the lake, and the surface of the lake is proportionately lower, the shallower part around Belle Isle at Bowness will become land, and Windermere will become two distinct lakes.

Looking southward, the lower lake was stated to be twenty fathoms deep, and the outline of the sea was pointed out, in the far horizon, broken by hills of Carboniferous limestone, which range from Ulverston through Cartmell and Grange.

The Skelgill Beck was then ascended and the succession of Coniston Limestones, Mudstones, and the overlying Graptolitic Shales seen, and fossils collected therefrom.

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FIGS. 197-200.—DIAGRAMS ILLUSTRATING THE PHYSICAL HISTORY OF EDENSIDE (see Proc. Geol. Assoc. vol. xi. p. 268).

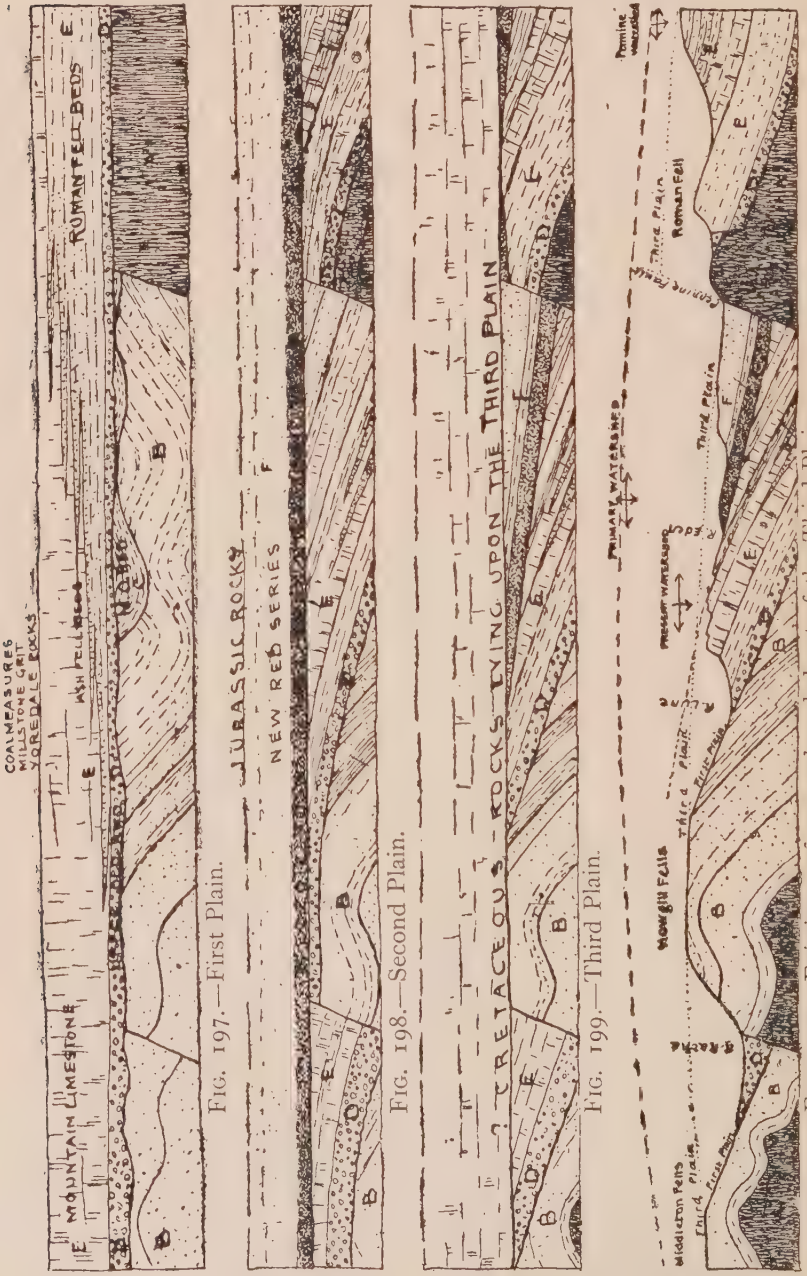


FIG. 197.—First Plain.

FIG. 198.—Second Plain.

FIG. 199.—Third Plain.

FIG. 200.—Existing surface, as denuded out of the Third Plain.

FIG. 201.—SECTION FROM SHALK BECK, ABOVE EAST CURTHWAITE (N.), ACROSS WARNELL FELL (S.).
(About six miles.)

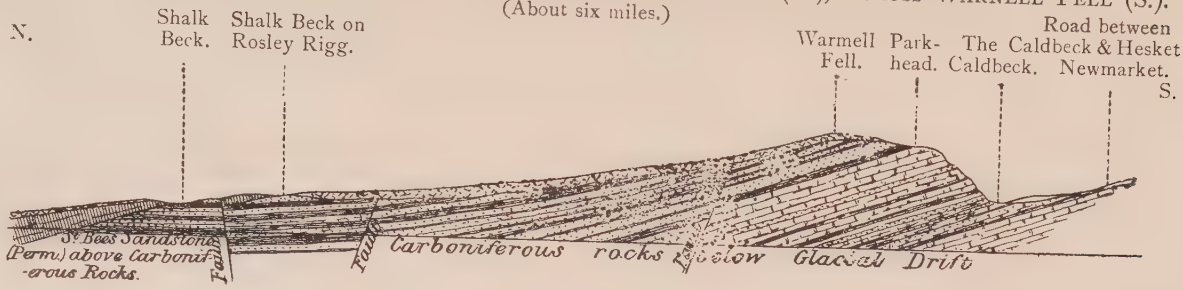


FIG. 202.—DIAGRAM-SECTION ACROSS NORTH-WEST CUMBERLAND
To show the Order of the Superficial Deposits.

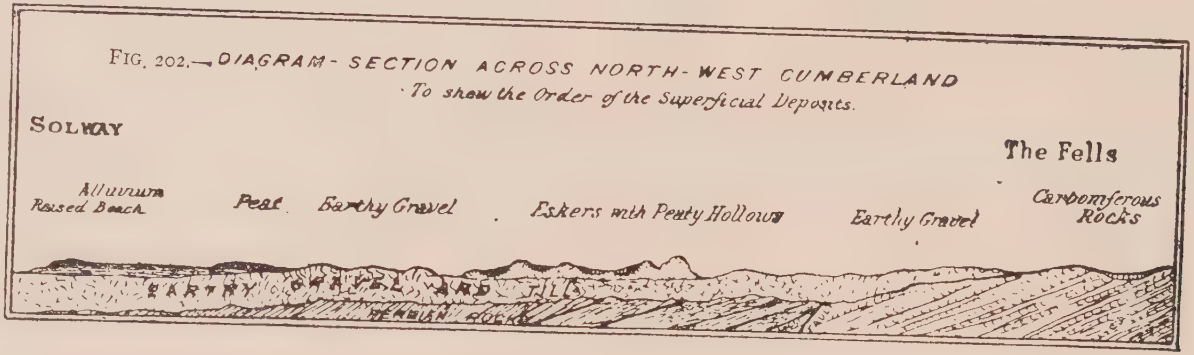
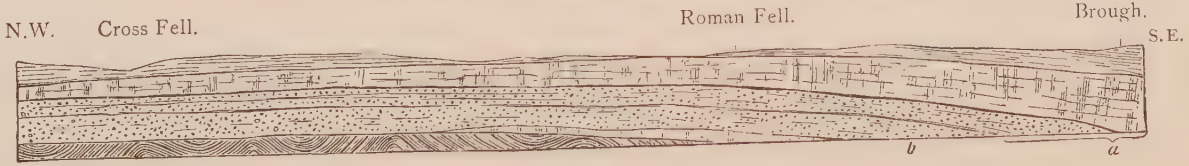


FIG. 203.—DIAGRAM SECTION FROM THE HOWGILL FELLS TO ROMAN FELL.

FIG. 204.—DIAGRAM SECTION ACROSS THE CROSS FELL ESCARPMENT.



[An excursion to *North-west Cumberland* and *Edenside* took place in August, 1890, the Directors being T. V. Holmes and J. G. Goodchild. The headquarters throughout the excursion was *Carlisle*. See Proc. vol. xi. p. 85. For papers by the Directors on the geology of North-west Cumberland see the same number of the Proceedings (vol. xi. No. 5, pp. 201-282). A list of papers on the geology of the district visited is given on pp. 282-4.

FIG. 205.—SECTION TO ILLUSTRATE THE NECESSARY THINNESS OF THE STANWIX MARLS IN CALDEWGATE, W. OF CARLISLE, INDICATED BY THEIR ABSENCE BENEATH THE ALLUVIAL FLATS.

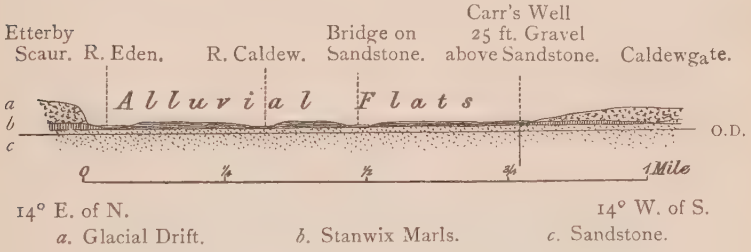
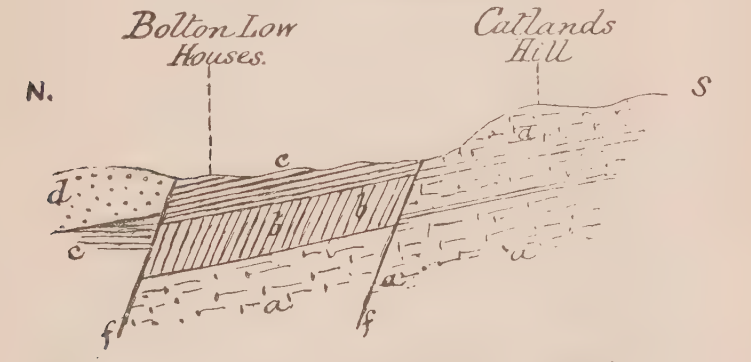


FIG. 206.—DIAGRAMMATIC SECTION FROM CATLANDS HILL TO BOLTON-LOW-HOUSES.



a C Limestone, b Beds in Chalk Beck, c Coal measures, d St Bees Sandstone, f Faults.

FIG. 207.—SECTION ACROSS THE CARLISLE BASIN FROM GRETNA TO WARWICK.

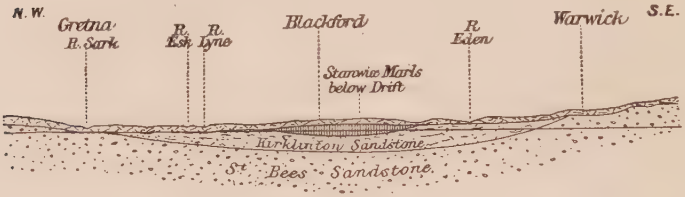
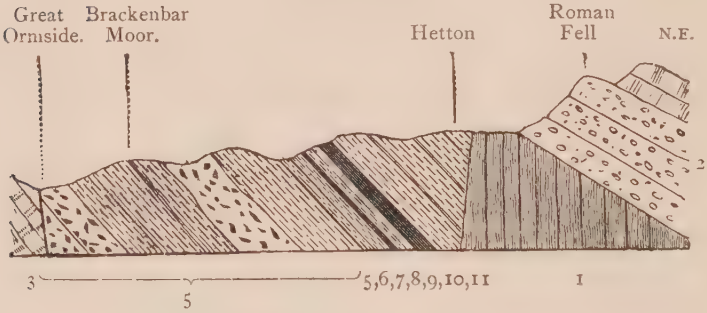


FIG. 208.—SECTION ALONG HETTON BECK, SHOWING THE SUCCESSION OF THE NEW RED ROCKS.

Length five miles.



1. Older Palæozoic Rocks.
2,3. Old Red Conglomerate and Carboniferous Rocks.
4. Penrith Sandstones and Breccias (1,200 ft.)
5. Plant beds (20 ft.)
6. Thin-bedded red Sandstone (50 ft.)
7. Grey Shale (3 ft.)
8. Dark-coloured Sandstone (6 ft.)
9. Magnesian Limestone (7 ft.)
10. Red Shales (100 ft.)
11. Upper Sandstone (700 ft.)

} Fossiliferous series.

[An excursion to *Northumberland* was made in August, 1886, the Directors being W. Topley, F.R.S. (President), and Prof. G. A. Lebour. One day, however, was devoted to the neighbourhood of *Marsden Rock* on the coast of *Durham*. The districts around *Newcastle*, *Hexham*, *Rothbury*, *Alnwick* and *Belford* were visited. For Report see Proc. vol. ix. p. 582. In the same number (No. 8) pp. 555-581, is a sketch of the geology of Northumberland by Prof. Lebour.]

FIG. 210.—DIAGRAMMATIC SECTION THROUGH NORTHUMBERLAND.

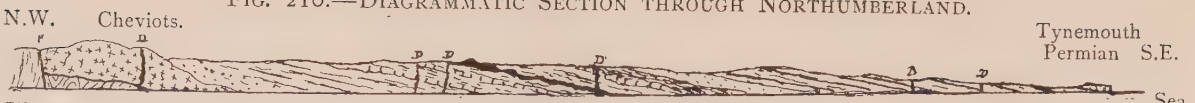


FIG. 211.—SECTION OF THE LOWER PERMIAN ROCKS IN THE CLIFF AT TYNEMOUTH PRIORY.

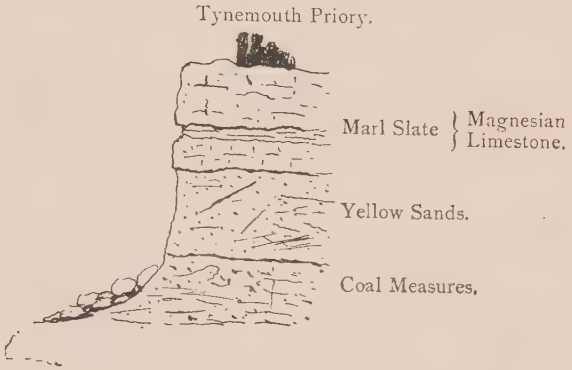


FIG. 212.—SECTION EXPOSED IN THE RIDSDALE IRONSTONE PITS (LOWER BERNICIAN).

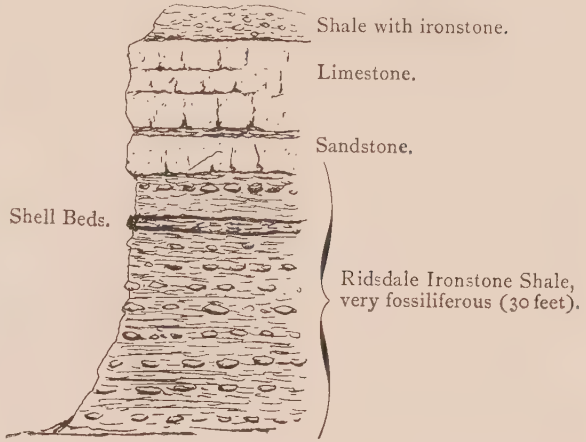


FIG. 213.—SECTION FROM TYNEMOUTH TO CULLERCOATS, ACROSS THE 90-FATHOM DYKE.

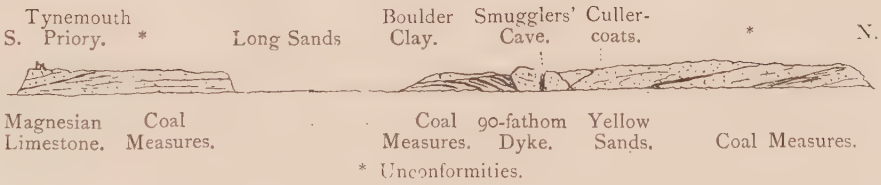
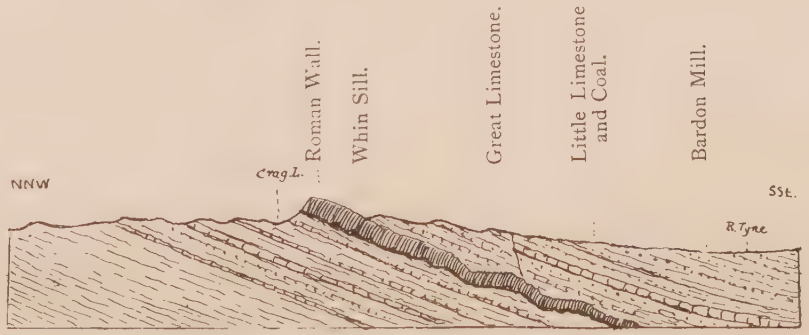


FIG. 214.—SECTION FROM BARDON MILL TO CRAG LOUGH.



FOREIGN EXCURSIONS.

EXCURSION TO BOULONNAIS.

MONDAY, AUGUST 5TH, 1878, AND FIVE FOLLOWING DAYS.

Directors—EDM. PELLAT, Dr. CH. BARROIS, Prof. GOSSELET, M. RIGAUX, Dr. SAUVAGE, and S. R. PATTISON, F.G.S.

(*Report by* C. BARROIS.)

(*Proc. Vol.* vi. *p.* 39.)

LEAVING London by the tidal train, the members of the Association arrived at Boulogne at 3.40 p.m., and were there joined by the Directors, by several members of the Société Académique de Boulogne and of the Société Géologique du Nord. They proceeded through the town to the Etablissement Municipal des Bains, where M. A. Huguet (the Mayor of Boulogne) gave a welcome to the Geologists' Association and invited the members to lunch.

After a short stay the party drove to Wimereux, and then came back to Boulogne along the shore, seeing the fine section of the Portlandian and Kimeridgian cliffs. Several French geologists joined the party.

The following beds were observed in the cliffs south of Wimereux :—

(Section 1.—Upper Oolites.)

W. Sands and ferruginous sandstones, with *Unio* (Wealden).

P. { P^4. Travertine, Cypris bed of Dr. Fitton (Purbeck).
P^3. Siliceous limestone, with *Cardium dissimile* . } Portland Stone.
P^2. Sands and sandstones, with *Natica ceres* and *Trigonia gibbosa*. . . . . } Portland Stone.
P^1. Sands and sandstones, with *Trigonia radiata* and *Serpula coacervata* . . . . } Portland Stone.

O.	O^2. Glauconitic clays, with *Ostrea expansa*	Portland Sand.	
	O^1. Clays with *Cardium morinicum* .	Hartwell Beds.	
M.	N^4. Sandstone, with *Pterocera oceani* . . .		French Portlandian.
	N^3. Sands, with *Pernæ*		
	N^2. Conglomerate, with *Trigonia Pellati* . .		
	N^1. Sandstone, with *Ammonites portlandicus (gigas)*		
M^2.	Superior shales and limestones of Chatillon . .		
M^1.	Inferior shales and limestone of Chatillon, with *Ammonites pseudomutabilis*		Virgulian.
L.	Sands and sandstones of Moulin Hubert . .		
K.	Superior clays and limestones of Moulin Hubert cliff, with *Ammonites caletanus*		
J.	Sands and sandstones of Conningthun . . .		Ptérocérian.
I.	Inferior clays and limestones of the Moulin Hubert cliff, with *Ammonites orthoceras* . . .		

The beds are described in the "Proceedings" by M. Pellat. Mr. Hudleston pointed out that the Boulonnais Upper Portlandian reminded him more of the appearance of the Purbeckian and Portlandian, as seen at Swindon, than of the Portlandian limestones of Weymouth. An ammonite similar to the *A. Portlandicus* of P^1 is found in England, both in the Portland Stone and in the Portland Sand.

Mr. Dowker pointed out the interesting fact that the rock with *Astarte socialis* had been used in the Roman buildings of Kent.

Prof. Giard called the attention of the party to the fact that the beds bored by recent *Tapes* are found on the shore at a higher level than that at present inhabited by those animals.

The party returned to Boulogne, Hotel du Louvre, for the night.

Tuesday.—The members left Boulogne in carriages at 8 a.m. and drove to Mount Lambert, where the section from O. to I. was seen; the party then proceeded to Echinghen to see the lower beds, from I. to E. of the section. The members of the Association then left Echinghen, and, directed by MM. Pellat, Rigaux, and Sauvage, proceeded to Belle, Mount des Boucards, Le Wast, and Les Pichottes, where the following beds were successively seen:—

H. Thirteen beds and small beds of Brequenecque, with *Pholadomya hortulana.*

G. Sandstone of Wirvigne, with *Pygurus jurensis.*

F^3. Marls, oolites, and sandy limestone of Bellebrune.

F². Clays, with *Ostrea deltoïdea*, and compact limestones, with *Lithodomi*.

F¹. Pisolitic limestone, with large *Nerineæ* of Hesdin l'Abbé.

E. Siliceous limestones of Echinghen, with *Astarte Morini* and *Trigonia Bronni*.

D. Clays of Brucdale, with *Ostrea deltoïdea*, of which the clays with deltoïdean *Ostreæ* of the Mount of Boucards appear to be the equivalent.

A. Coralline Limestone of Brucdale. The Coralline Limestone of the Liane Valley and some limestones below it have probably their equivalents in the north and east of the Boulonnais in the limestones of the Mount des Boucards.

6. Limestones of Houllefort, with *Opis* and *Pseudomelania heddingtonensis*.

Upper beds of the Liégette, with *Am. Martelli* and sponges.

5. Clays and limestones with *Terebratula impressa* and *Millericrinus* in the middle beds of the Liégette.

4. Black clays of the north of Le Wast, with small pyritous Ammonites—*A. Rengeri*, &c.

3. Marly, splintery limestones of the south of Le Wast, with *Am. Lamberti*.

2. Clays and sandy limestones, south of Le Wast, with *Serpula vertebralis* and and *Ammonites Duncani*.

1. Ferruginous clays of Belle and Alincthun, with *Ammonites calloviensis*.

Cornbrash, at Pichottes.

Mr. Hudleston is of opinion that the Oolite F¹ is probably of the age of the higher Corallian beds of the Weymouth district; the sandstone of Wirvigne (G) may be classed as a sort of Upper Calcareous Grit. The limestone of Houllefort should be correlated with the Coralline Oolite, or possibly with shelly passage beds at the top of the Lower Calcareous Grit.

The party started late from the Cornbrash pits of Pichottes and arrived at Boulogne at night.

WEDNESDAY.—The members started this day by the 7 a.m. train for Marquise. The following is the sequence of the Lower Oolites as shown to the party by Drs. Sauvage and Rigaux in the Rinxent railway cuttings, and in several pits around Marquise:—

D. Siliceous and oolitic limestone Belle and Bellebrune, with *Rhynchonella badensis*, identical with the English Cornbrash.

C. Marly limestone, burnt for lime, with *Rhynchonella elegantula*, equivalent to the *Forest marble;* numerous *Acrosalenia Lamarcki.*

B. Marquise oolitic limestone, with *Rhynchonella Hopkinsi*, considered as representative of the siliceous limestone of Minchinhampton.

A. Hydrequent limestone (Fuller's Earth), with *Ostrea Sowerbyi* and *Modiolæ* in the lower part, and Gasteropods and Brachiopods in the upper part; it rests on pyritous and lignitous sands.

After breakfast at Marquise the party proceeded to Hydrequent pits, where Professor Gosselet took the direction of the excursion. There the marly limestones of the Fuller's Earth, with *Ostrea Sowerbyi*, rest on the denuded surface of the Carboniferous Limestone.

In following the Haut-banc Valley are seen good sections of the Mountain Limestone series in the following order:—

Shales (Coal Measures).
Sandstones of the Plaines (Millstone Grit).
Limestone, with *Productus giganteus.*
Napoleon Limestone, with *Productus undatus.*
Limestone of the Haut-Banc, with *Productus cora.*
Dolomite of Le Hure.

The members of the Association did not succeed in finding any fossil plants in the Coal Measure shales of the Hardinghen mine, but they were fortunate enough to find in them several brackish-water shells of the genera *Anthracomya* and *Anthracosia*, totally unknown before in the Coal Measures of Boulonnais.

At Hardinghen the Palæozoic rocks are covered by the *Am. mammillaris* zone of the Gault, worked for the phosphatic nodules it contains. From Hardinghen the party went back to the Rinxent railway station, and then by train to Boulogne.

Thursday.—We left Boulogne, as on the preceding day, by the 7 a.m. train to Marquise; there, after breakfast, we began, with Professor Gosselet and several members of the Société Géologique du Nord who had joined us, a complete section of the Palæozoic rocks of Boulonnais, from Blecquenecques to Caffiers.

North of Blecquenecques are several pits, where is quarried a tough, violet-bluish limestone, with *Productus cora* and *Lithostrotion*, covered by a whitish compact limestone, with *Spirifer glaber Productus undatus* (Napoleon Marble). These limestones are

broken by a fault. The Coal Measures are worked north of the fault, and the seams pass below the Carboniferous Limestone (Napoleon Marble) seen before; further north, below the Coal Measures, is found the regular series of the Palæozoic beds. The series of the beds is the following in descending order:—

11. Coal Measures of Locquinghen, with *Pecopteris Loshi*, *Sphenopteris coralloides*, *Sphenophyllum erosum*, *Annularia radiata*, *Calamites Suckowi*, &c.
11. The Plaines of Hardinghen Sandstone (Millstone Grit), with *Productus Flemingi*.
10. Limestone, with *Productus giganteus*.
9. Napoleon Marble, with *Productus undatus* and *Spirifer glaber*.
8. Haut-banc Limestone, with *Productus cora*.
7. Dolomite of Le Hure Mill, with crinoidal remains.
6. Fiennes Sandstone, with *Cucullæa Hardingi* and *C. trapezium*. Below are found the red shales that we consider of the same age as those met with in the deep well of the Meux Brewery, London.
5. Ferques Limestone, with *Spirifer Verneuili*, *S. Bouchardi*, *Atrypa reticularis*, *Rhynchonella bononiensis*, *Cyathophyllum hexagonum*, and *Favosites bononiense*.
3, 4. Shales of Beaulieu, with *Spirifer Verneuili*, *S. Sauvagei*, *S. Barroisi*, *Strophomena Gosseleti*, and *Cyrtina heteroclita*. In the middle of this formation is the Dolomite of les Noces.
2. Blacourt Limestone, with *Orthis striatula*, *Cyrtina heteroclita*, and *Productus subaculeatus*.
1. Conglomerates, red shales, and green sandstones of Blacourt, ferns, calamites.

Silurian.

Mr. J. Grant found *Spirifer Orbelianus* (Abich) in the Blacourt Limestone, a form only hitherto known in Ardennes and in Russia.

M. Rigaux called attention to the sub-divisions of the Beaulieu Shales, where he has traced the following palæontological zones:—

Limestone, with *Pentamerus brevirostris*.
Marl, with *Streptorhynchus elegans*.
Clay, with *Streptorhynchus Bouchardi*.
Shales, with *Spirifera Davidsoni*.

Professor Gosselet spoke on the geological history of the Palæozoic Rocks of Boulonnais, and of their relation with the formation of the Ardennes and of the Mendip Hills.

Dr. Barrois noticed the connection between the disturbances of these strata and the formation of the Hercynian Mountain system by lateral pressure.

The party then proceeded to Caffiers, and then by train to Boulogne. In the evening they went, at half-past nine, to the Folkestone Hotel, where they had been invited to a tea-lunch by the Société Académique and the Société Médicale of Boulogne.

Friday.—Leaving Boulogne by the 7 a.m. train the members arrived at Calais, where they were waited for by M. Lejeune, one of the Curators of the Calais Museum. The members first visited the collections of the Museum, and were specially interested with the remarkable series of flint implements found in the neighbourhood and in Boulonnais by M. Lejeune.

After breakfast they drove to Sangatte, where the interesting cores found in the dredgings in the Channel and the other preparatory work for the tunnel between England and France, were exhibited by M. Potier, chief engineer in care of the scientific part of the work. They then also visited the collection of Cretaceous and post-Tertiary fossils found in the neighbouring cliffs by Dr. Robbe.

The party then left Sangatte with M. Potier and Dr. Robbe, who acted as Directors at the Cretaceous cliffs during the whole day. They walked along the beach to Wissant, seeing on their way, in the Blanc nez chalky cliffs, the following palæontological zones in descending order :—

15. Post-Tertiary beds of Sangatte.
14. Outlier of iron-sand (Crag ?).
13. Flinty Chalk, with *Micraster breviporus*.
12. White Chalk, with *Terebratulina gracilis*.
11. Nodular hard Chalk, with *Inoceramus labiatus*.
10. Marl, with *Belemnites plenus*.
9. Marl, with *Ammonites rotomagensis*.
8. Marl, with *Ammonites varians*, and bed with *Plocosyphia meandrina* at the base.
7. Chloritic Marl, with *Ammonites laticlavius*.
6. Grey Marl, with *Ammonites inflatus*.
5. Deep-blue Clay, with *Ammonites interruptus*.
4. Bed of Phosphatic Nodules, with *Ammonites mamillaris*.
3. Green Sandstone and Sands (Folkestone beds).
2. Black Clay, with *Exogyra sinuata* (Sandgate beds).
1. Ferruginous Sand (Wealden).

Arrived at Wissant some of the party returned to Calais with

MM. Lejeune, Potier, and Robbe. The majority then drove back to Marquise, where the train took them back once more to Boulogne.

Saturday.—The party went by train to Pont-de-briques and then walked to St. Etienne-au-Mont. At the top of the hill Wealden iron ores, sands, and clays are quarried. Dr. Barrois spoke of the conditions of the Lower Cretaceous of Boulonnais as compared with those of the Weald of Kent; Mr. J. Parker pointed out the resemblance of the Wealden beds of St. Etienne to the sands and iron ores on the top of the Oxfordshire hills.

The party continued the section to Ecaux, where several diggings for iron ore were seen. M. Pellat has found *Cyrenæ* and *Trigoniæ* in this iron ore, and thinks it to be of Portlandian age.

From Ecaux the members proceeded to the Alpreck lighthouse, where the equivalent of the Portland Stone is very fossiliferous. They then returned to Boulogne by the top of the cliffs, where the beds N^1 and N^2 are quarried: *Am. Portlandicus*, ripple and plant markings were found.

This trip concluded the first foreign excursion of the Association. Before leaving Boulogne the members of the Geologists' Association invited to dinner the French Directors of the excursion, and left Boulogne by the evening boat.

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[The Report in vol. vi. (pt. 1) of the Proceedings is illustrated by a series of sections, especially lent for the occasion.]

BELGIUM.

An excursion to *Belgium* and the *French Ardennes—Brussels, Givet, Dinant, Namur, Grotto of Han*, &c., took place in August, 1885. The Directors were E. Dupont, Director of the Royal Museum, Brussels, and of the Geological Survey of Belgium, Prof. J. Gosselet, of Lille, and Dr. J. C. Purves, of the Geological Survey of Belgium. It is reported by W. Topley and Miss Mary Forster, Proc. vol. ix. (No. 4), p. 261. In the same number are papers by Professors Gosselet and Bonney on the Geology of Belgium, fully illustrated.

ITALY.

In addition to the ordinary programme for the year, an extra excursion to the *Volcanic Regions of Italy* was organised by the Association in the year 1889. It originated in a proposal made by Dr. Johnston Lavis, a member of the Association residing in Naples, who became its chief Geological Director. The latter half of September was devoted to *Sicily* and the *Lipari Islands*, and the whole of October to the districts around and between *Naples* and *Rome*. A full account of this Italian tour is given by Dr. Lavis in the Proceedings for August, 1890 (vol. xi. No. 8).

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